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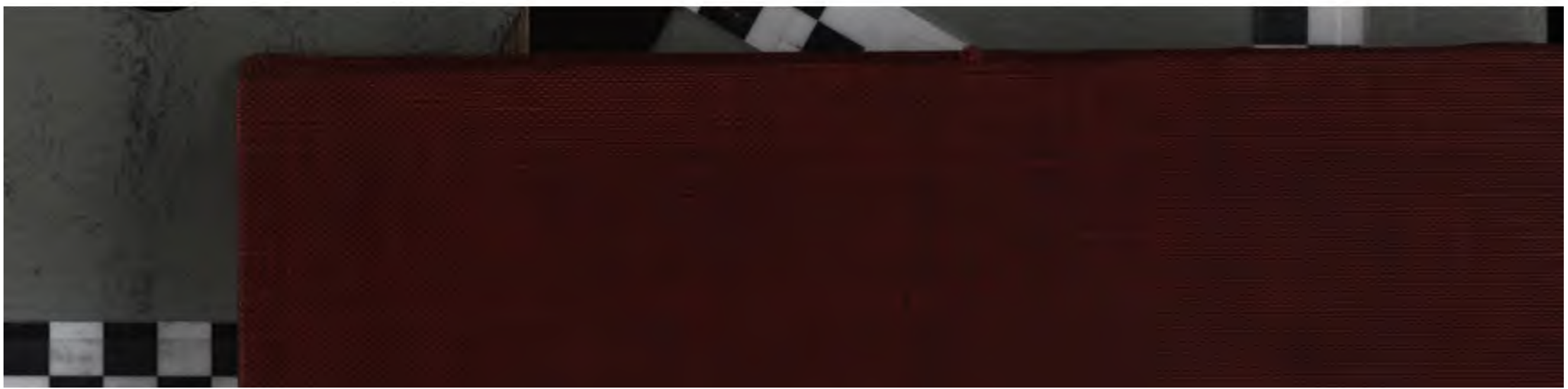

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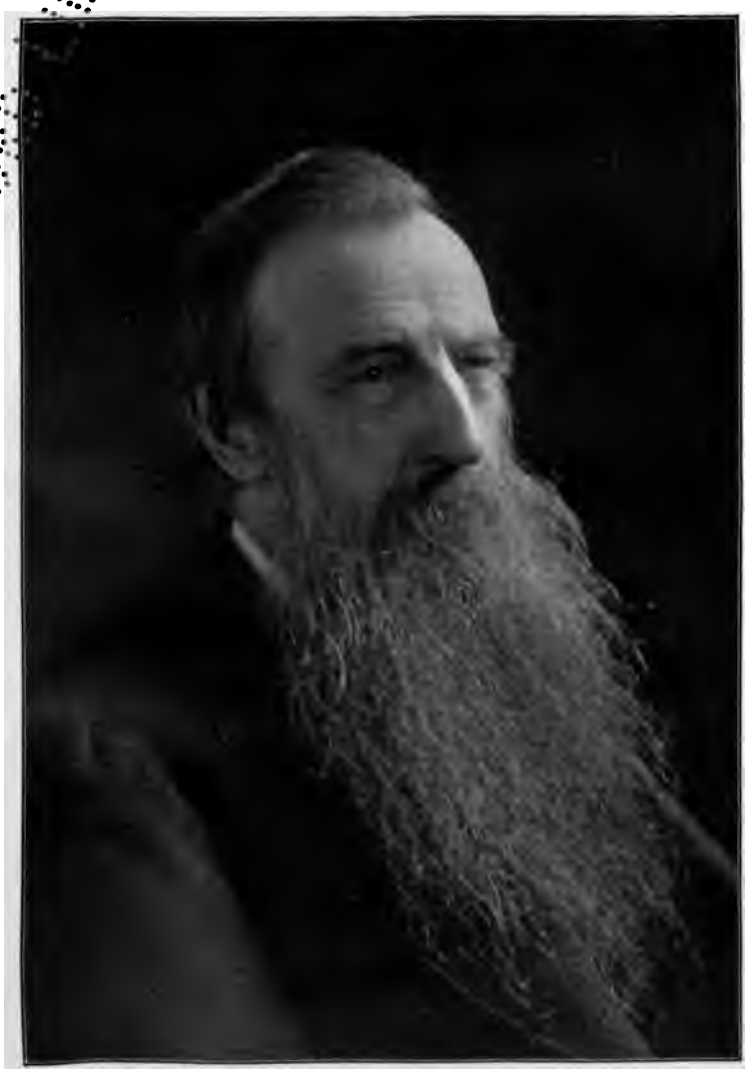

ALEXANDER BUCHAN, LL.D., F.R.S.

(*Symons Medallist*, 1902)

Frontispiece, Quart. Journ. Roy. Met. Soc. vol. xxviii. *From Photo by Elliott & Fry.*

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CONTENTS.

PAGE

The Exploration of the Atmosphere at Sea by means of Kites. By A. Lawrence Rotch, B.Sc., M.A., F.R.Met.Soc. Director of the Blue Hill Meteorological Observatory, U.S.A. (Five Illustrations) . 1

Meteorological Phenomena in relation to Changes in the Vertical. By Prof. John Milne, F.R.S. (Two Illustrations) . . . 9

Further Observations and Conclusions in relation to Atmospheric Transparency. By the Hon. F. A. Rollo Russell, F.R.Met.Soc. . 19

Damage by Lightning at Higher Brookland, Devon, June 30, 1901. By C. Grover. (Two Illustrations) 27

Remarkable Phosphorescent Phenomenon observed in the Persian Gulf, April 4 and 9, 1901. By W. S. Hoseason, of the s.s. *Kilwa* . 29

Mean Temperature of the Atmosphere and the Causes of Glacial Periods 32

On the Mechanical Principle of Atmospheric Circulation. By Capt. R. A. Edwin, R.N., F.R.Met.Soc. (Abstract) 33

Proceedings at the Ordinary Meeting, November 20, 1901 . . 34

Proceedings at the Ordinary Meeting, December 18, 1901 . . 34

Correspondence and Notes:—

Meteorological Office, Rome 35

Mauritius Meteorological Society 35

Hourly Velocity of the Wind at Rousdon. (Illustration) . 36

Report of the Cowl Committee 38

Deaths and Fires caused by Lightning in Hungary . . 38

Registration of Bright Sunshine at the Royal Alfred Observatory, Mauritius 39

Barograph Trace during Typhoon, August 2-3, 1901. (Illustration) 39

Wind Force in Tornadoes 40

Observations of the Edinburgh Rock Thermometers . . 41

Cloud Photograph. (Illustration) 41

Cyclonic Storms in the Bay of Bengal 42

PAGE

Recent Publications 44

The Element of Chance applied to various Meteorological Problems. An Address delivered to the Royal Meteorological Society, January 15, 1902. By WILLIAM HENRY DINES, B.A., President. (Four Illustrations) 53

Atmospheric Dust 68

Report on the Phenological Observations for 1901. By EDWARD MAWLEY, F.R.Met.Soc. (Plate I. and Two Illustrations) . . 69

Meteorology in New South Wales, 1901. By H. C. RUSSELL, F.R.S. . 94

"La Lune mange les Nuages"—A Note on the Thermal Relations of Floating Clouds. By W. N. SHAW, F.R.S., F.R.Met.Soc. (Two Illustrations) 95

Climate of Manila 101

Symons Memorial Medal. (Plate II.) 102

Proceedings at the Ordinary Meeting, January 15, 1902 . . 103

Proceedings at the Annual General Meeting, January 15, 1902 . 103

Proceedings at the Ordinary Meeting, February 19, 1902 . . 105

Correspondence and Notes :—

Meteorological Notes in South Africa 105

Prize Competition for Apparatus for measuring Wind Pressure . 106

The "De Witte Typhoon," August 1-6, 1901 . . . 107

Meteorological Congress, Mexico, 1900 . . . 109

Cumulus Clouds formed by Smoke 112

Recent Publications 112

The Prevalence of Gales on the Coasts of the British Islands during the Thirty Years 1871-1900. By FREDERICK J. BRODIE, F.R.Met.Soc. (Thirty-one Illustrations) 121

The State of the Ice in the Arctic Seas, 1901 157

Clouds. A Lecture delivered to the Royal Meteorological Society, April 16, 1902. By Capt. D. WILSON-BARKER, R.N.R., F.R.S.E., F.R.Met.Soc. (Eight Illustrations) 159

Lightning Photographs 167

Formation of Cloud 168

Report of the Council for the Year 1901 169

Sound Signals and Weather 173

Balance-Sheet for the Year 1901 174

Inspection of Stations, 1901. By WILLIAM MARRIOTT, F.R.Met.Soc., Assistant-Secretary 178

Obituary Notices 184

PAGE

Books purchased during the Year 1901 197

Donations received during the Year 1901 198

Reports of Observatories, etc. 205

Royal Meteorological Institute of the Netherlands . . . 211

Weather Bureau, Queensland 211

Rainfall at San Fernando, Spain 211

Proceedings at the Ordinary Meeting, March 19, 1902 . . 212

Proceedings at the Ordinary Meeting, April 16, 1902 . . . 212

Correspondence and Notes :—

The Barograph Trace during the Typhoon, August 2-3, 1901 . 212

Cumulus Clouds formed by Smoke. By H. MELLISH . . 214

Loss of Life in the United States by Lightning . . 214

Recent Publications 215

Report on the Wind Force Experiments on H.M.S. *Worcester* and at Stoneness Lighthouse. By W. H. DINES, B.A., Pres. R.Met.Soc., and Capt. D. WILSON-BARKER, F.R.S.E., F.R.Met.Soc. (Five Illustrations) 217

The Cornish Dust-fall of January 1902. By HUGH ROBERT MILL, D.Sc., LL.D., F.R.Met.Soc. (Eleven Illustrations) . . . 229

Distribution of Fog in Switzerland 252

English Climatology, 1891-1900. By FRANCIS CAMPBELL BAYARD, F.R.Met.Soc. (Illustration) 253

Solar and Meteorological Changes 281

Weather Bureau, Queensland 282

Earth Temperature Observations recorded in Upper India. By W. L. DALLAS, Assistant Meteorological Reporter to the Government of India. (Three Illustrations) 283

Proceedings at the Ordinary Meeting, May 21, 1902 . . . 300

Proceedings at the Ordinary Meeting, June 18, 1902 . . . 300

Correspondence and Notes :—

Investigation of the Upper Atmosphere by means of Kites . 300

Convention of United States Weather Bureau Officials . . 301

Eclipse Meteorology and Allied Problems . . . 301

Rainfall Maps of the United States 302

Pressure and Temperature Results for the Great Plateau of South Africa 302

Recent Publications 304

Index 309

PLATES.

Frontispiece. Alexander Buchan, LL.D., F.R.S. (Symons Medallist, 1902).

PLATE

I. Map showing position of the Phenological Stations, 1901.

II. The Symons Memorial Medal.

ERRATUM.

Page 24 line 23. *For* north-west *read* south-west.

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THE EXPLORATION OF THE ATMOSPHERE AT SEA BY MEANS OF KITES.

BY A. LAWRENCE ROTCH, B.Sc., M.A., F.R.Met.Soc.,
Director of Blue Hill Meteorological Observatory, U.S.A.

[Read November 20, 1901.]

THE use of kites to obtain meteorological observations at Blue Hill Observatory has been described in *Quarterly Journal Royal Meteorological Society*, vol. xxiii. pp. 251-252, and vol. xxiv. pp. 250-259, and I have successfully carried on the work of exploring the air at that station to a height of three miles by several hundred kite-flights executed in varied weather conditions, whenever the velocity of the wind on the ground was between 12 and 35 miles per hour. Certain types of weather, therefore, such as anticyclones, accompanied by light winds, can rarely be studied, and the same is true of cyclones when attended by severe gales.

In 1898 the United States Weather Bureau equipped 17 stations with kites, in order to obtain daily observations at the height of a mile, for forecasting the weather. The experiment failed because the light winds of summer prevented flights from being made regularly at all the stations. Nevertheless, many data were obtained concerning vertical temperature-gradients over a wide area in the central part of the United States.

The employment of kites in meteorology was begun about the same time on the continent of Europe. At Trappes, near Paris, my colleague, Mons. Teisserenc de Bort, has reached with his kites altitudes exceeding those at Blue Hill, while the Aeronautical Observatory of the Royal Prussian Meteorological Institute, near Berlin, is, at the present time, the most completely equipped establishment of the kind in the world.

The systematic exploration of the atmosphere above the continent of Europe has been in progress for several years, under the direction of

an International Committee of which I am the American member. Ascents of manned balloons, and of balloons, carrying recording instruments only, to still greater heights, are now made each month in France, Germany, Austria, and Russia, and kites are used to supplement the observations at the highest altitudes. It frequently happens, however, that on the day of the balloon-ascension the wind at the ground is insufficient to raise the kites. Since the balloons drift with the upper currents to considerable distances, the comparison of the data obtained from them with observations made at any station on the ground is more or less uncertain.

Although it has been stated (*Quarterly Journal Royal Meteorological Society*, vol. ix. p. 63) that on the Island of Igloolik (lat. 69° 21′, long. 81° 44′ W.) a kite had been used to obtain the temperature of the upper air in Hudson's Strait, I do not find any record of the use of kites to elevate instruments from the deck of a moving vessel. It is related in the Appendix to Capt. Parry's *Journal of a Second Voyage for the Discovery of a North-west Passage from the Atlantic to the Pacific in* 1821-3 (p. 187), that a registering thermometer was raised by a paper kite to the height of 400 feet above the ocean without showing any change in temperature, and in Capt. Back's *Narrative of an Expedition in H.M.S. "Terror" on the Arctic Shores in the Years* 1836-7 (p. 165), it appears that, when the ship was fast in the ice, a Six's thermometer, lifted 1200 feet perpendicularly by a kite, read 8° lower than on the ice. It is stated on page 328 that there were very few occasions when the wind and ice were favourable for these experiments.

The method which I wish to propose obviates the necessity of having a suitable wind to fly the kites, and consequently renders it possible to obtain at almost all times information about the upper air and in regions hitherto inaccessible. Briefly stated, it is the employment of kites carrying meteorographs on steamships, especially on vessels cruising in tropical oceans. Kites can be used on shipboard more frequently and probably to better advantage than on land, since they can nearly always be flown from either a stationary or a moving ship. For example, when the air is calm, by steaming through it at a speed of 10 or 12 knots, the kites can be raised to the height that they would reach in the most favourable natural wind, and, on the contrary, the force of strong winds can be proportionately reduced if the vessel moves with the wind. Often, while there is sufficient wind near the surface, it fails entirely at the height of the *cumulus* clouds, and in this case it would only be necessary to put the ship in motion to carry the kites through the calm zone and into the upper current that may suffice to lift them.

To make these observations properly requires a vessel that can be started, stopped, and turned at the will of the meteorologist, who may thus explore the heights of the atmosphere, just as the hydrographer and zoologist have explored the depths of the ocean. Had the *Challenger* Expedition been provided with our modern kite-apparatus, and accompanied by meteorologists trained in their use, it might have accomplished the double task of sounding the oceans of air and water. The German Antarctic vessel *Gauss* and the *Discovery* of the English Antarctic Expedition are each equipped with meteorological kites which were to be used on the southern voyage begun last August, but it is to be feared

that this branch of the meteorological work, being subordinate to the main aims of the expedition, will always be sacrificed to them. In any case it must be remembered that scientific kite-flying requires practical and skilful operators, and without them and much reserve apparatus will yield mediocre results.

The handling of kites on steamships presents no serious difficulty, for power is available at all times to operate the kite-winch, and the wire from it may be led over a pulley on a yard-arm, capable of being turned so as to bring the kites clear of the rigging, etc. The launching of a kite from a ship is easier than on land, owing to the greater steadiness of the wind at sea, and especially of the artificial wind created by the

FIG. 1.—Tug-boat from which the first Experiments were made, August 22, 1901. (Kites were flown from K.)

ship's movement. Wherever the observations in the upper air may be made, there is always the observing station on the ship at sea-level, and not far distant horizontally, with which to compare them. Although observations above all the oceans are valuable, the equatorial region is the most important to be explored, for, with the exception of a few observations in the Andes and on mountains in Central Africa, we know nothing of the thermal conditions prevailing a mile or two above the Equator. The need of such data to complete our knowledge of the circulation of the atmosphere was stated by the Russian meteorologist, Dr. A. Woeikof, at the Meteorological Congress of 1900 in Paris. Within the Trade-wind belts, north and south of the equator, kites might be employed to determine the height to which the trades extend, and also the strength and direction of the upper winds, concerning which the high clouds that are rarely seen in those latitudes give us what little information we now possess.

The atmosphere above the equatorial oceans can be best explored by a vessel having a speed of not less than 12 knots, and possessing sufficient

FIG. 2.—Dominion Line S.S. *Commonwealth* leaving Boston, August 28, 1901. (Kites were flown from K.)

deck-room to permit of handling the kites. A boat suitable for the purpose is the *Princess Alice*, the exploring yacht of the Prince of Monaco,

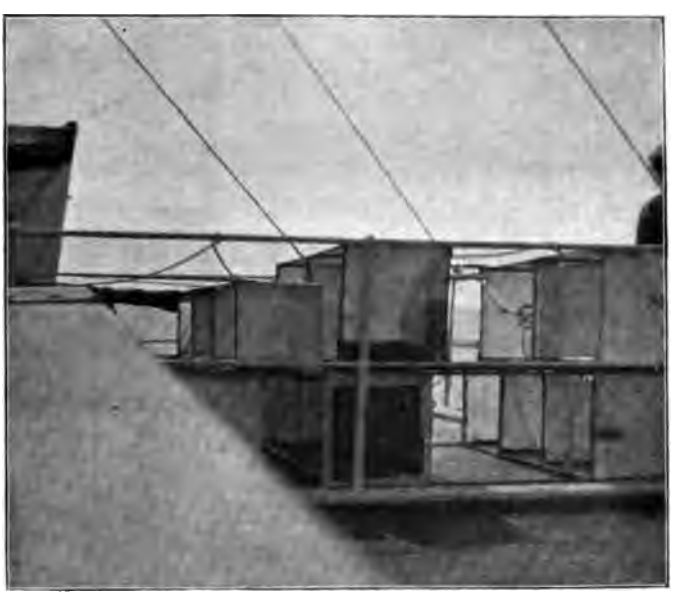


FIG. 3.—Kites stored on S.S. *Commonwealth*.

who has manifested interest in my project. Meanwhile the German meteorologist, Dr. W. Köppen, is proposing to make observations with

kites from a sailing vessel bound across the equator, but it is evident that the main advantage mentioned would be lost on a vessel driven by the wind.

The use of kites on a vessel that could be manœuvred at will was demonstrated by me on a tow-boat (Fig. 1) in Massachusetts Bay on August 22, 1901. Anticyclonic weather conditions prevailed, and the velocity of the wind at sea-level varied between 6 and 10 miles an hour, but at no time was sufficient to raise the kites either there or at the Blue Hill Observatory. The maximum speed of the tow-boat was 10 miles an hour, but, by altering the course of the boat with respect to the wind, an artificial wind of 0 to 18 miles an hour was created, the angle through

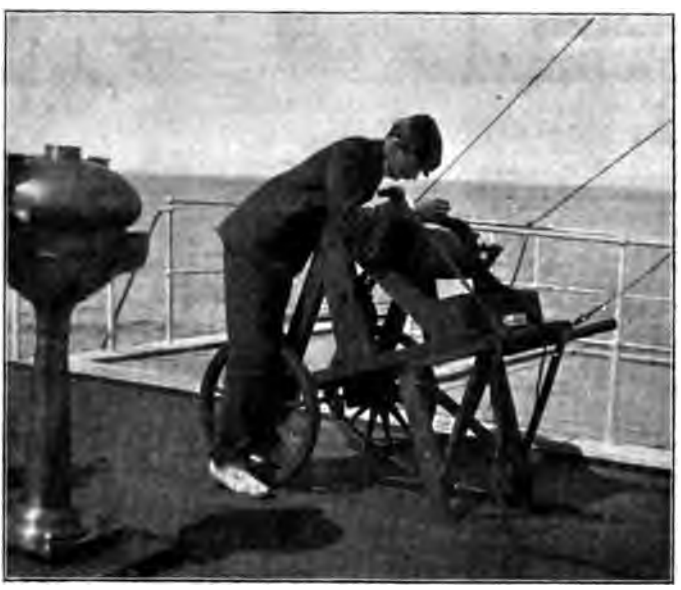


FIG. 4.—Kite-Reel on after-deck of S.S. *Commonwealth*.

which the boat could be turned and still provide sufficient wind for the kites being about 90°. The uniformity of the artificial wind facilitated launching the kites, which rose with great steadiness at a high angle, carrying the meteorograph to an elevation of half-a-mile.

I next endeavoured to obtain meteorological data with kites on a steamer crossing the North Atlantic, and, through the courtesy of Capt. James M'Auley, the kites and apparatus were installed on the after-deck of the Dominion Line steamship *Commonwealth* (Fig. 2), which left Boston for Liverpool on August 28, 1901. Anticyclonic weather conditions prevailed during most of the voyage, and the wind blew only 4 to 12 miles an hour, but, since the vessel steamed 15 or 16 knots, it was possible on five days out of the eight to use the kites. On the remaining three days the relative wind on the ship was either too light, owing to a following wind, or too strong on account of a head wind, to permit the kites to be flown safely, but, had I been free to change the course of the vessel, flights could have been made every day. While no trouble was

experienced in making the flights, the small kites (Fig. 3) and the hand-winch (Fig. 4) employed precluded reaching an altitude greater than 610 metres or 2000 feet. Synchronous records were obtained from a meteorograph hung above the deck, with which the upper-air records were compared, and the two series of meteorograms obtained in Mid Atlantic on three consecutive days are given in Fig. 5.

The chief feature of these records is the rapid change of temperature with height. The average decrease of temperature in four of the flights was 1°·8 F. per 100 metres, which is the adiabatic rate for dry air, but in

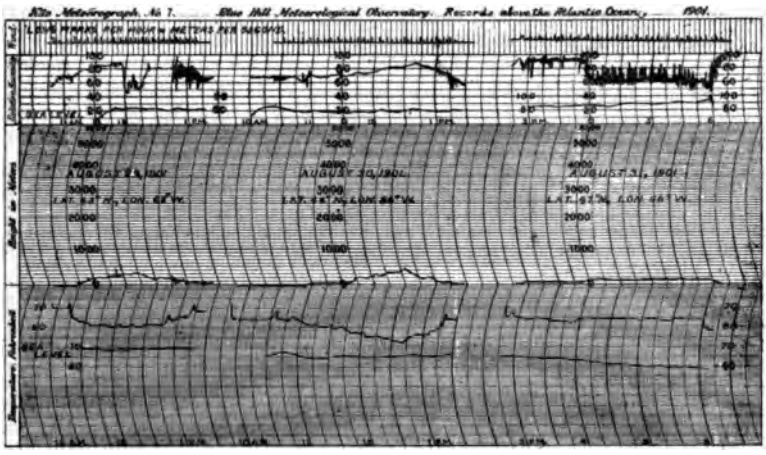


FIG. 5.—Meteorograms obtained in Mid Atlantic, August 29, 30, and 31, 1901.

one instance the decrease was 3°·2 for the first 100 metres. In the flight on August 31 the air was 5°·6 warmer at the height of 130 metres than it was at sea-level, and remained so during the afternoon. There was usually a stratum of nearly saturated air a short distance above the ocean, and above that air becoming drier, but in the highest flight the humidity continued to increase with increasing altitude, which is the condition on land up to the cumulus clouds. The wind generally increased with altitude, and in four out of five cases veered aloft towards the right-hand when facing it On the next westward voyage of the *Commonwealth* the resultant winds were too strong to permit the kites to be flown. It is evident that kite observations, if made only when the conditions were favourable, would go far towards showing whether the conditions prevailing over the ocean differ from those above the land, and would also furnish information about the upper air in atmospheric situations that cannot be explored with kites at a fixed station.

DISCUSSION.

THE PRESIDENT (Mr. W. H. DINES) remarked that they were indebted to Mr. Rotch for the interesting account of his investigation.

Mr. W. N. SHAW thought that the extension of the investigation of the upper air from land stations to the sea was likely to prove very interesting. So far the temperature gradient had proved very variable both for different times and for different places, and any rule as to the fall of temperature with increasing altitude, such as that formulated by Mr. Glaisher, could only be applicable in a statistical sense and not to individual observations. At present we had no knowledge of the laws of these differences. It would be desirable to carry out observations in places where the changeable conditions of our latitudes did not exist, as, for instance, in equatorial regions or the regions of the trade winds. It might thus be possible to throw light upon the obscure problem of general atmospheric circulation. It was satisfactory to note that the use of ships would make the carrying out of the observations possible. He was himself much interested at present in the determination of the variation of temperature with height, because of its influence upon the persistence or disappearance of floating cloud. He had lately come to the conclusion that it depended upon the temperature gradient whether a cloud became thicker or thinner in consequence of the communication or abstraction of heat, as by the sun shining upon it, or by radiation at night.

Mr. F. C. BAYARD drew attention to several thickenings of the traces of the meteorographic chart, and inquired if they were the result of mechanical defects in the instrument, or were occasioned by the rapid changes in altitude of the kite.

Dr. H. R. MILL said that Mr. Rotch in this paper had drawn attention to what Prof. von Bezold speaks of as the most important development of meteorology at the "turn of the century," *i.e.* the exploration of the upper air. Any new method for carrying out this work more thoroughly was of great value. He could not say how long ago the idea was first entertained of using kites on boats, but he remembered reading the specification of a patent for a ship being hauled along by kites, and which must have been raised from the vessel at rest. While accompanying the *Discovery* as far as Madeira on her voyage to the Antarctic regions, he had assisted in several experiments in kite-flying, while the vessel was under both sail and steam, and no doubt further experiments would be made during the progress of the voyage. Mr. Rotch had already promised that if a steamer were provided he would be prepared to provide the apparatus and the personnel for carrying out the investigation. The use of kites for exploring the upper air was originated in this country, and he hoped the work would still be carried on here. In this connection he was happy to be able to say that at the last meeting of the British Association a committee was appointed to co-operate with a committee of this Society in initiating a fresh series of experiments.

Mr. R. BENTLEY suggested that the smudging of the traces pointed out by Mr. Bayard was possibly due to the meteorograph passing through a cloud at the time, which would occasion cooler and moister conditions.

Capt. A. CARPENTER thought that Mr. Rotch should endeavour to get the United States Weather Bureau to take up the question. The American hydrographic surveying vessels did a great deal of excellent deep-sea research and they would no doubt assist in such experiments. He thought a sailing vessel was unsuitable owing to the spread of canvas aloft, the number of ropes about the deck, and the heel of the ship. A passenger steamer was bound to follow her course, which might make too much wind for the kite or reduce it

to too little. H. M. surveying vessels are too full of work to make any prolonged experiments, but if some definite point was required to be elucidated which would not involve much loss of time, it is possible that our own Hydrographic Department might be approached on the subject. He thought the *Challenger* expedition had quite enough to do in exploring the depth of the ocean, and could not be expected to attend to the ocean of air.

Capt. D. WILSON-BARKER thought Mr. Rotch's paper most opportune; the record of his experiences could not fail to be of great service to the Society, which was about to try similar experiments. He quite agreed with Mr. Shaw as to the value of such observations in settling points which were at present merely theoretical. He thought it possible useful experiments might be carried out on Telegraph Ships, could they enlist the services of officers or others, as many opportunities would occur on such vessels. He would be glad if they could learn something from Mr. Rotch of the expenses of these experiments—the cost of kites and apparatus, and the amount of risk of breakage.

Mr. R. H. CURTIS asked within what limits the indications of the instruments used could be relied upon as correct; because, if they were subject to the same amount of error from friction, etc., as the mechanical barographs and thermographs usually employed at the ground level, it was quite possible that their "lag" might result in somewhat large errors, both in respect of the height attained and also the temperature at different levels. He had recently examined some barograms taken from a self-registering aneroid, in which the reading of the curve was nearly one-tenth too low when pressure was increasing briskly, and as much too high when pressure was changing in the opposite way. Possibly the jerking to which the apparatus would be subjected when attached to a kite might to some extent neutralise the friction.

Mr. C. HARDING said that Mr. Rotch was an ardent observer and was doing good work in the cause of meteorology. He thought that Mr. Shaw was quite right in regard to individual observations. He could well imagine that great changes would take place both in humidity and temperature on breaking through a cloud. Mr. Glaisher had long ago pointed out that at sunset the temperature was lower on the earth's surface than at some distance above it; and this fact ought to be taken into consideration when tabulating the results of these experiments. To eliminate all possibility of error the observations should be grouped according to time.

[Mr. A. L. ROTCH replied by letter to the Secretary: "The thickening of the traces on the kite-meteorograms was usually due to the jerks of the kites, which had the advantage suggested of preventing the pens from sticking. However, the rapid fluctuations of relative humidity in the trace of the hygrometer on August 31 were caused by the suspension of the meteorograph just above a damp current, into which it dipped at intervals. The sensitiveness of the thermometer was such that it recorded a change of 25° within the space of five minutes, and during any ascent or descent changes of this amount never occurred without the instrument remaining a longer time at a nearly constant level, for at least ten minutes were required to record the velocity of the wind. The height was usually calculated from an angular measurement and the length of wire, the trace of the barometer being only employed when the upper kite could not be observed. The cost of apparatus for exploring the air to a height of two miles, allowing two meteorographs at £20 each, a duplicate set of five kites, 10 miles of wire, and a hand-winch, would be about £140."]

METEOROLOGICAL PHENOMENA IN RELATION TO CHANGES IN THE VERTICAL.

By Prof. JOHN MILNE, F.R.S.

[Read November 20, 1901.]

All who are familiar with Horizontal Pendulums are aware that these instruments can without difficulty be so adjusted that they accurately follow changes in the vertical through angles considerably less than one second of arc, and however carefully they may be installed they indicate that such changes are almost continually in progress.

With the object of determining how far these movements were influenced by local conditions, between 1893 and 1895, whilst resident in Japan, I obtained series of photographic records of these displacements from nineteen different installations. Three of these were in caves, the instruments being founded on rock, one was in an underground chamber excavated in the alluvium of the Tokio plain, whilst the remainder were on the surface, in laboratories or specially constructed huts. The more important displacements recorded may be referred to as "long," "intermediate," and "short period" wanderings.

Long Periodicities.

For several months the boom of a pendulum installed in the meridian may wander through several or many seconds of arc towards the west, after which it will return towards the east. At times the movements appear to follow the seasonal changes in temperature, but, as pointed out by the late Dr. E. von Rebeur-Paschwitz and as observed by myself, we may have the turning points in the curve showing the displacement of the pendulum following and then preceding the points of inflection of the temperature curve by one to four months. This want of synchronism between change in temperature and the direction of pendular movement renders the relationship between these two phenomena obscure. Local change of temperature in the room where a pendulum is installed may affect the same, but the result of my experience is that, if the temperature of such a room be raised 30° F., the effect on the instrument is less than that which frequently takes place when the natural change is only 4° or 5° F. What the effect of changes in the average temperature of the district around a station where a pendulum is established may be is not known. Neither has the effect of the accumulation of barometric pressure over an ocean, as compared with the relative diminution of the same over an adjoining continental area, been clearly demonstrated. If the pendulum should swing towards the area of greatest barometrical pressure, then the long period movements which I have observed in Japan hardly favour such a supposition. This, however, is contrary to the views of Mr. F. Napier Denison, whose observations are referred to in the next section.

Intermediate Periodicities.

Superimposed upon these long period movements, each of which occupies several months, are irregular displacements, each of which occupies several days. Periods of two to seven days are common, and the displacement in one direction may be rapid, not occupying more than 12 to 24 hours. These represent deflections of from 2 to 5 seconds of arc.

Observations made in Japan have shown that certain of these movements are connected with barometric changes and the alternation of wet and fine weather. At one station near Tokio an instrument which recorded motion parallel to the dip of the rocks on which it was installed, although it was less sensitive than an instrument recording motion parallel to the strike, recorded the greatest tilting.

Interest in what is apparently this type of movement has been revived by a paper entitled "The Seismograph as a Sensitive Barometer," contributed by Mr. F. Napier Denison on June 19, 1901, to the Royal Meteorological Society (*Quarterly Journal*, vol. xxvii. p. 293). Mr. Denison tells us that at Victoria, British Columbia, where he is stationed, the movements of a Horizontal Pendulum precede those of the local barometer, and even those of a sensitive hydro-aerograph, whilst the direction of the movement is to the side of highest barometrical pressure.

As a continuation of my previous work on this subject, and with the object of throwing additional light upon Mr. Denison's observations, after referring to short period movements, I desire to draw attention to the nature of the information bearing upon irregular changes in the vertical which, during the last 4 or 5 years, have been accumulated in the Isle of Wight.

Short Periodicities.

Many observers have drawn attention to the existence of a diurnal and occasionally a semi-diurnal movement of Horizontal Pendulums. At one installation in the Isle of Wight these attain amplitudes of from 1 to 2 seconds of arc. This station is on the eastern slope of a north-south valley, which is bounded by chalk downs and has a stream along its bed. The pendulum is pivoted at its northern end and points towards the south. Generally the movement of this may be described as one that follows the sun. In the morning it moves towards the south-east when the sun appears above the downs, and as the sun proceeds south to set in the west the south end of the boom follows the same. During the night it returns towards its normal position. As in Japan, it is observed that these movements are pronounced on fine bright days, whilst they are feeble or absent when it is dull or wet. They differ greatly in amount in different localities. In flat open country, or underground on rock they may be small, whilst on ground with an irregular contour, as, for example, on the edge of a scarp, they may be very large. In this latter position unusual movements observed on frosty nights are probably of a different order to the ordinary diurnal wave. Pendulums pointed east and west apparently show that the north-south component of the diurnal wave is small.

I have attributed the cause of the diurnal wave to the unequal removal

of loads from two sides of a station, such removals being the result of evaporation and vegetable transpiration.

A fourth class of movement to which pendulums are subject are more or less continuous swingings, with periods varying between a few seconds and two or three minutes. Under the name of "air tremors," "earth tremors," and "microseismic movements," etc., the descriptions of these form a vast literature. The extent to which real earth tremors have been confused with those due to extremely local meteorological conditions is uncertain. Air tremors may be pronounced in one room but absent in a neighbouring apartment. They may be frequently destroyed by giving additional ventilation to a room, or keeping a lamp or gas-jet burning in the same.

The possible relationships of these various pendular movements have been considered in respect to local barometric pressure, barometric gradients, temperature, atmospheric moisture, frost, dew, wind, rain, waves, earthquakes, and other phenomena (see Reports on Seismological Investigation, published by the British Association 1883, 1884, 1885, 1887, 1888, 1893, 1895, 1896. For a more complete account of this work, see the *Transactions* and *Journals* of the Seismological Society of Japan). An epitome of the same is contained in *Seismology*, Int. Sci. Series.

Theoretical investigations bearing upon this subject are to be found in a Report to the British Association, 1882, by Prof. G. H. Darwin, F.R.S., and in a paper on the "Application of Physics and Mathematics to Seismology," *Phil. Mag.*, March 1897, by Dr. Charles Chree, F.R.S.

Observations in the Isle of Wight.

To illustrate the nature of pendulum displacements which during the last five years have been continuously recorded in the Isle of Wight, I have taken the records for the first six months of 1901. These records, which show the displacements of a Milne horizontal pendulum, are on photographic films which moved at the rate of 1 mm. per minute beneath the outer end of the boom. From a datum line photographed on one edge of the films the displacement of the image of the boom has been measured at 6 a.m., noon, 6 p.m., and at midnight, and these measurements have been plotted as shown by the thin lines in Fig. 1.

The diurnal wave is shown by many of the sharp zigzags, each of which has approximately a twenty-four hours' period. These, it will be observed, are more marked during the bright weather of April, May, and June than they are in the earlier portion of the year. In certain instances, as, for example, about April 24, these have magnitudes exceeding 2″, and, as might be anticipated, they are quite sufficient to exaggerate or obliterate deflections due to other causes.

The thick curve was obtained by drawing a free curve through the sharp sinuosities. The result is that we now see that the long period wandering of the pendulum from January 1 to May 15 has been about 20″ to the westward, after which, until June 11, a retrograde motion was established. Superimposed on this are many irregularities representing accelerations or pauses in the westerly motion or temporary retrogressions towards the east. These superpositions are the "intermediate periodicities."

To determine whether these are related to fluctuations in barometrical pressure, in the upper part of Fig. 1 a curve of barometric gradients has been plotted. These were obtained from Weekly Weather Charts issued by the Meteorological Office, which show the isobars over the British Islands and a great portion of Central and Western Europe at 8 a.m. and 6 p.m. for each day. As it is reasonable to suppose that only the east and west component of a gradient could influence the movement of a pendulum in the meridian, the quantities taken from any chart is the difference in pressure reckoned in tenths of inches between two points, one approximately 300 miles to the east and the other 300 miles to the west of the Isle of Wight. If the high pressure is to the east then this quantity is plotted above the zero line, and if to the west it is plotted below the same. The curve of gradients, therefore, shows periods when high pressure was to the east or to the west of the Isle of Wight. When in the east we should expect the pendulum to move in that direction, or at least be checked in its long period displacement towards the west, the converse taking place when the pressure was on the west.

The curves for gradient and pendulum motion might therefore be expected to follow the same direction. The causes interfering with such possible synchronism are diurnal tilting, the effect of rain, the running off and evaporation of the same, and the long period march which may be towards the east or towards the west. When the diurnal wave reaches 2″ this is probably equivalent to an easterly and then a westerly gradient of ·3 inch per 600 miles.

The effect of heavy rainfall which accumulates on the west side of the Isle of Wight station is to carry the pendulum in that direction. This and the subsequent dissipation of the rain load results in displacements very much greater than those due to the diurnal wave. When, therefore, either of these conditions prevail, effects resulting from barometric pressure may be obliterated. Therefore, whilst reading the following notes, these considerations should be kept in view.

Movements of the N.-S. Horizontal Pendulum at Shide, Isle of Wight, in relation to Barometric Changes.

1900. December 30.—From 8 a.m. a depression moved from the north-west of Ireland across Devon, and at 8 a.m. was over the north-west of France. While the centre of this was to the west of the Isle of Wight (until after 6 p.m. on the 30th) the Horizontal Pendulum moved eastwards, but when it was on the east the pendulum moved west.

Until January 3rd the high pressure is slightly to the west; the pendulum moved west also.

From January 3rd, 6 a.m., to 7th, 6 p.m., anticyclonic conditions "dominated these islands" and Central Europe, but the isobars were far apart, and their east and west components were small, and changed but little in their values.

On the morning and evening of the 8th a depression appeared off the north-west coast of Spain. On the 9th this advanced north-eastwards across the Bay of Biscay, and crossed the mouth of the Channel. It was of great intensity, the lowest reading being 29·2 ins., but local. On the 10th and 11th this "filled up," the centre moving northwards and then westwards across Ireland.

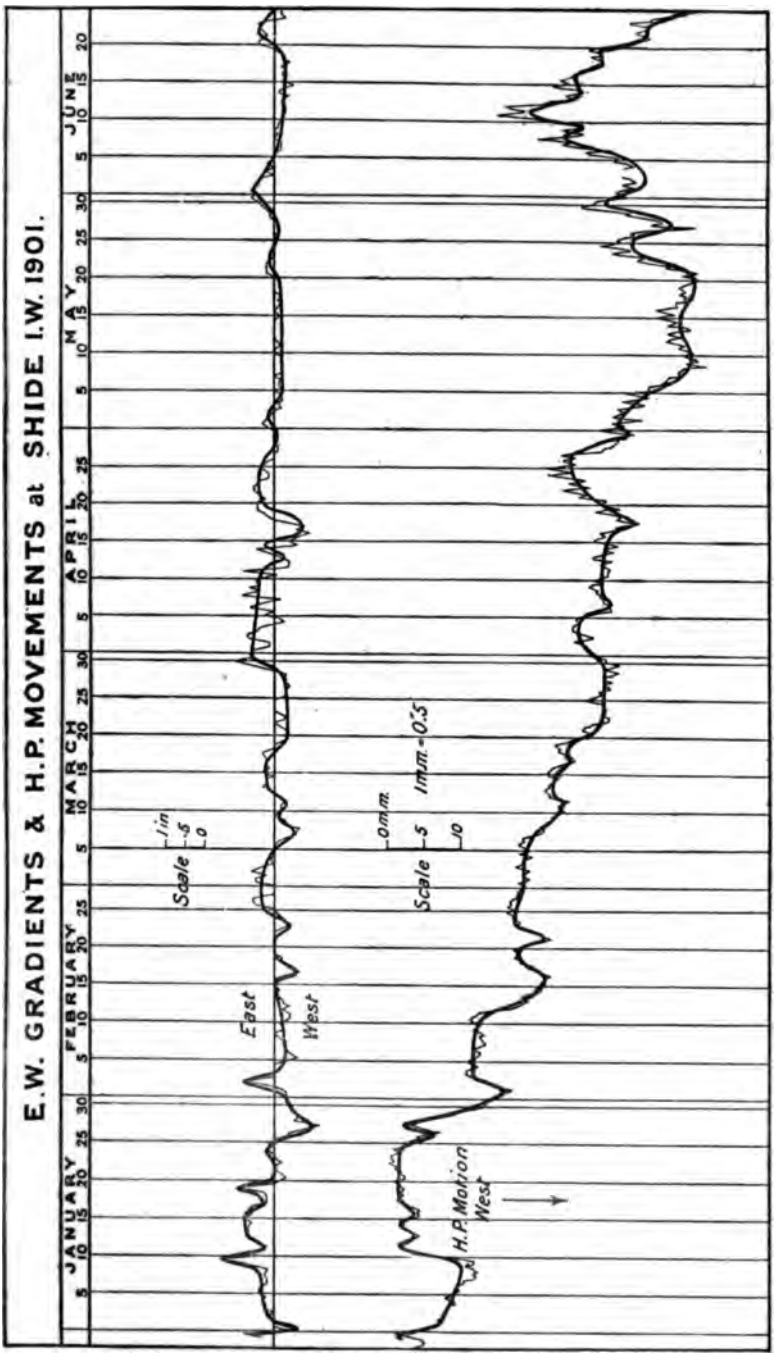

E.W. GRADIENTS & H.P. MOVEMENTS at SHIDE I.W. 1901.
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
Scale 1in
East
West
0m.m.
Scale 1m.m.=0.5
H.P. Motion
West

FIG. 1.

The differences in pressure between that at the centre and that over the Isle of Wight were as follows:—

		Distance and Direction of Centre.	Difference in Pressure.
January	8, 6 p.m.	91 km. S.W.	·4 in.
,,	9, 8 a.m.	52 ,, S.W.	·4 ,,
,,	9, 6 p.m.	30 ,, W.	·5 ,,
,,	10, 8 a.m.	50 ,, W.N.W.	·2 ,,
,,	10, 6 p.m.	55 ,, N.W.	·1 ,,
,,	11, 8 a.m.	64 ,, N.W.	·1 ,,

Between January 9th, 6 p.m., and 11th, 8 a.m., the general change in pressure on the west side of the Isle of Wight was approximately equivalent to adding a load exceeding $\frac{1}{10}$ inch along a line exceeding 40 km. in length. During this interval the pendulum moved 8 mm. eastwards, or the vertical changed about 4″. The relationship between the movement of the pendulum and that of the local barometer will be seen by reference to Fig. 1.[1]

From the 10th to the 20th the high pressure remained to the east, whilst the pendulum retained its easterly position attained during the storm of the 9th.

The sudden shift of pressure from the east to the west on January 19th was not marked in the pendulum record.

From the following day until February 25 the high barometer was generally to the west of the Isle of Wight, and during this period of 36 days the pendulum was intermittently creeping to the side of this westerly load.

On January 27, February 2, 5, 15, and 23, the pressure on the western side is more or less suddenly reduced, and in one instance (February 2), by conditions very similar to those which prevailed on January 9th, it is actually converted into an eastern load. Each of these fluctuations apparently finds a response, if not by bringing about a retrograde motion in the pendulum's westerly march, by at least causing a pause in the same. A pause of this description is seen between February 25 and March 5, during which period an easterly load prevailed.

From March 6th to 12th, under the influence of a westerly load, the pendulum again proceeded in a westerly direction.

From the 12th to the night of the 18th these conditions, and with them the swing of the pendulum, were reversed.

The interval between the 19th and 29th was one of varying westerly pressure, and corresponding to the same the pendulum proceeded 7 mm. farther towards the west.

The next period, March 30 to April 11, was one of easterly load, with many fluctuations in value, corresponding to which we see that the westerly march of the pendulum was arrested, and it frequently turned to the east and to the west as the eastern load fluctuated in value. We can here trace the influence of rain, which apparently causes the pendulum to turn westward, whilst the barometric load should cause a displacement in the opposite direction.

[1] The relationship of load to tilt here given, and the relationships which may be inferred from the figures, must be received with caution. They are certainly much greater than would be anticipated from the investigations of Prof. G. H. Darwin and Dr. C. Chree.

From the 11th to the 16th the load was to the west, and the pendulum followed the same, but did not, however, reach its limit until the 17th.

From this date until April 25th it returned towards the east, accompanying an easterly load which did not disappear until the 26th.

The next period, which lasted until May 27th, or 32 days, was one during which the gradients were small and almost entirely westerly. During the first 12 days the pendulum crept 10 mm. or 5″ to the west. This it did in an intermittent manner, the diurnal variations being large. Under a fairly constant western load it retained this position during the next 12 days, ending on May 12th. On this date, and continuing until June 5th, the barometric load was to the east, and the pendulum rapidly but very irregularly followed the same.

From June 5th to the 11th the pendulum continued its eastern course, whilst the pressure shifted to the west, and we have an illustration exactly the opposite of what would be anticipated.

RAINFALL AT THE GRAMMAR SCHOOL, NEWPORT, ISLE OF WIGHT, JANUARY 1 TO JUNE 30, 1901.

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	Date.	Jan.	Feb.	Mar.	Apr.	May.	June.
1	·02	·13	·06	...	...	·01	17	·07	·02	...	...	...	...
2	...	·30	·20	·05	...	...	18	·36	·02	...	...	...	...
3	...	...	·26	·64	...	...	19	·02	...	·25	...	...	·27
4	...	·45	·07	·05	...	...	20	...	...	·45	...	...	·02
5	...	...	·13	·54	·01	...	21	...	·01	...	...	...	·14
6	...	...	·09	·03	·09	...	22	...	...	...	...	...	...
7	·44	...	·05	·10	·01	...	23	...	...	...	...	...	...
8	·13	...	·03	·01	·01	...	24	·02	...	...	...	...	..
9	...	...	...	·11	·20	...	25	·04	·01	·12	...	...	·12
10	...	...	...	·33	...	·01	26	·04	·30	...	...	...	...
11	...	...	...	·07	...	...	27	·07	·02	...	...	...	...
12	...	...	...	·06	...	·15	28	·04	·52	...	·01	...	...
13	...	...	...	·18	...	·15	29	...		·08	...	·05	·36
14	...	...	...	·02	...	...	30	...		·81	...	·29	·54
15	·05	...	·18	·10	...	...	31	...		·03		...	
16	·22	...	...	·06	...	...							
							Total	1·52	1·78	2·81	2·36	0·66	1·77

Although this anomaly is met with in the Shide record, the same does not exist in that from Edinburgh, which closely followed the direction of change in gradients, and the same is apparently also true for Bidston.

The only explanation that can be offered for the abnormal movements of the Shide pendulum during the month of June is that the barometrical effect between the 5th and 10th (which effect, however, was not pronounced) was eclipsed by that due to drought, which removed more load from the valley side of the Shide station than was removed from the hill side. This would result in an easterly movement. Its westerly movement on the 20th, when it might be expected to turn eastwards, may have been due to the loading of the valley by rain.

Fig. 2 shows the wanderings for the month of June of Horizontal Pendulums at the Royal Observatory, Edinburgh, and the Liverpool Observatory, Bidston.

At Edinburgh the Observatory is situated upon a sheet of volcanic rock, and the mean daily range of temperature in the instrument room

is about 3°·5 F. The general form of the pendulum curve, the amplitude of which is about 2″, closely corresponds to that for barometric gradients, the serrations on the former apparently indicating a diurnal or semi-diurnal wave.

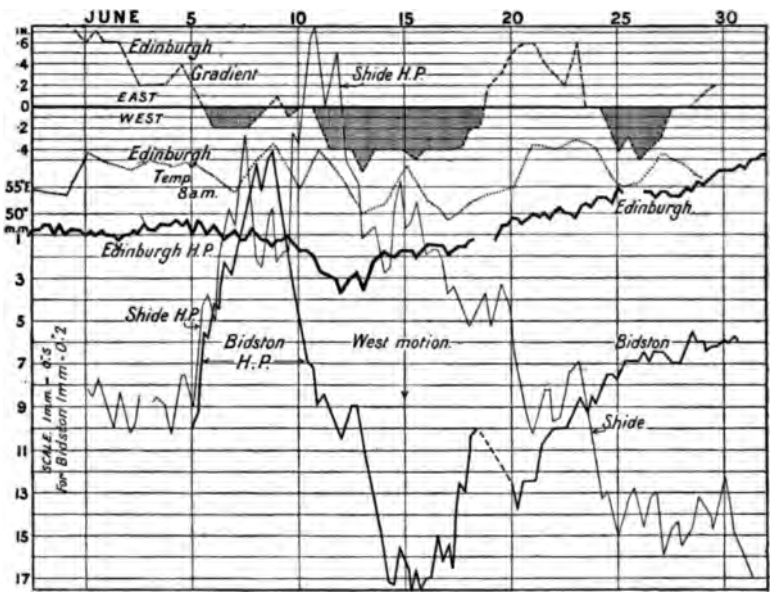


Fig. 2.

The instrument at Bidston is installed in a cellar excavated in the New Red Sandstone. The daily temperature change is 1°·5 F., and the annual change 12° F. The greatest displacement for the month has been about 4″, the scale value at this station being 0·2″ per 1 mm. displacement. The direction of displacement approximately corresponds to what might be anticipated from the change of gradients at Edinburgh, but is more nearly in accord with the gradients from Shide, from which a westerly motion would be expected to take place between June 6th and 14th, after which the trend should be eastwards. As before stated, the pendulum curve for Shide does not show any clear connection with the gradients, its wanderings in three instances at least having been influenced by rain.

At Kew the instrument, which is installed underground, has its boom pointing towards the north, the datum line on the film being on the west side.

The only records which have been examined relate to January and February. In one or two instances, as, for example, on January 9 and 10, and on February 16, the deflections of the pendulum apparently show a relationship to variations in barometric gradients, but generally the movements of the pendulum have been contrary to what would be expected as a result of barometric influences.

Conclusion.

From what has been said it appears that slow displacements of Horizontal Pendulums are of three types. Assuming that a locality can be chosen where the diurnal wave and effects due to rain and desiccation are small, which my observations indicate as possible, records of what appear to be the effects due to barometrical gradients may be obtained. When these are large and appear suddenly, the movements of the pendulum may be marked.

At Shide the westerly displacement of a pendulum has for several years past been regarded as indicating the approach of bad weather, and now Mr. Denison points out that the observation of these movements may be of value in making weather forecasts.

Whether sufficient has been done to justify a more careful examination of these movements at a properly selected station, it is for meteorologists to decide.

In conclusion, while thanking Mr. W. N. Shaw for the use of weather-charts, I also thank Dr. R. T. Glazebrook, Dr. C. Chree, Mr. W. E. Plummer, Dr. R. Copeland, and Mr. T. Heath for the loan of pendulum records obtained at Kew, Bidston, and Edinburgh.

DISCUSSION.

The President (Mr. W. H. Dines) said they would all agree in expressing thanks to Prof. Milne for his interesting paper.

Mr. R. H. Curtis said the seismograph was an instrument of extreme sensibility, and when more came to be known respecting the nature of the influences to which it was subject, it might possibly prove of value to meteorology, but at present it seemed clear that it could in no sense be regarded as a meteorological instrument. He had made an attempt to connect the movements of the traces shown on the diagrams with the atmospheric changes which occurred during the same interval, as shown on the charts published in the *Weekly Weather Reports* of the Meteorological Office, but the attempt had been unsuccessful. The trend of the boom seemed very often to be persistently in the same direction whether the centre of highest pressure was to the east or to the west of the station, and to be uninfluenced by the fact that the centre travelled right across the United Kingdom. Also he found that whilst the centre lay to the south-west and west of the British Isles, the Bidston instrument moved one way, the Shide instrument moved in the opposite direction, and the Edinburgh instrument varied in a way which was not quite in accord with the movements of either of the other two; and yet all three instruments should, he presumed, have been affected steadily in the same direction. An attempt to trace some connection between the diurnal range of pressure and the diurnal movements of the pendulum had also been unsuccessful. He recognised that the data at his command was not the best; but still he thought it would be safest for meteorologists to adopt for the present an attitude of reserve respecting the use of the instrument, and more especially so since Prof. Milne had himself intimated that a variety of phenomena were capable of affecting its movements.

Mr. R. Bentley remarked that it would be interesting to know if it had been possible for all magnetic disturbances to be eliminated from the trace recorded by the pendulum; and also how far purely artificial tremors of the air and earth affected the trace on the diagram ascribed to meteorological

influences. The well-known story of the pellicles of earth falling down in a garden in Kent at the time of the battle of Waterloo—the vibrations of the bombardment of Alexandria noticeable as far off as Malta—and the firing of the minute guns near the Isle of Wight at the time of the funeral of Her late Majesty in February last, were illustrations of accidental effects of a kind which might be traceable on the full-size record of the instrument, and which had to be excluded from the curves before they could be rigidly applied for meteorological purposes.

Mr. W. N. SHAW thought it was difficult to draw any final conclusion from Prof. Milne's interesting comparison of the variations of the horizontal pendulum with those of the barometric gradient. The pendulum was essentially a dynamical instrument, indicating small variations of the tilt of the ground in a particular direction. The tilt was associated with barometric gradient in some cases, but there were obviously many other causes which could produce a change of tilt. The pendulum could not be regarded as a meteorological instrument until the students of dynamics had sorted out and differentiated the causes upon which its indications depended. The curves could not be expected to exhibit any trace of the diurnal variation of the barometer, because, in the first place, that variation was distributed uniformly over very large areas, while the indications of the pendulum depended upon local variations; and, secondly, the diurnal variation was so small that its effect would certainly be marked by other dynamical causes.

THE PRESIDENT (Mr. W. H. DINES) said that if, at a station near the sea, the regular oscillation of the tides was not recorded by the boom, it was hopeless to expect that barometric oscillations could, by means of their varying pressure, produce any motion; for the changes of pressure on the sea bottom, produced by the rise and fall of the tide, were greatly in excess of those produced by the rise and fall of the barometer.

[Prof. J. MILNE replied by letter to the Secretary: "In the preceding paper, as will be seen by the last sentence in the same, it is not suggested that meteorologists should adopt the horizontal pendulum as a meteorological instrument, but simply consider the advisability of making a certain experiment. A reader of the remarks made by Mr. Curtis might infer that horizontal pendulums were altogether unaffected by barometric changes, which is not the case. When the barometric gradient, measured at right angles to the orientation of the boom of a properly installed instrument, *is great*, it frequently happens that there is a pronounced movement to the side of highest pressure. Magnetic disturbances do not affect horizontal pendulums, the moving parts of which are constructed of non-magnetic materials. Neither are they affected by the firing of heavy guns or the passing of vehicles, even when vibrations due to the same may cause an observatory to rattle. Air tremors thicken a trace, but do not influence the form of long-period displacements.

Displacements caused by tidal load have been measured and discussed by the late von Rebeur-Paschwitz.]

FURTHER OBSERVATIONS AND CONCLUSIONS IN RELATION TO ATMOSPHERIC TRANSPARENCY.

By the Hon. F. A. ROLLO RUSSELL, F.R.Met.Soc.

[Read December 18, 1901.]

IN previous papers on the subject of haze I have given the results of observations made during several years on the causes of opacity and transparency in the atmosphere, and have shown that in general, so far at least as Western Europe is concerned, haze is produced by a mixture of different winds or currents, and transparency by a steady wind of large extent or great depth.

The haze accompanying dry North-east winds was a phenomenon baffling explanation, so long as the close proximity of upper currents from a contrary direction was left out of account; but when it was understood that mixtures of currents of different temperatures are the chief cause of that slight visible deposit of moisture, as well as of dense mists and fogs, and that East winds generally have West winds above them, it was easily accounted for. On most occasions when fog prevailed on the ground, and admitted of a view of upper clouds, I had noted that these moved from a westerly point in opposition to the movement of the lower air. Stevenson's observations in Berwickshire, recorded by Buchan, showed that the upper current bearing cirrus cloud moved most frequently from South-west and North-west, and that "any one of the three directions—South-west, West, and North-west—was about equal to all the other five directions taken together."

In the tables of results for the years 1895 and 1897, showing the number of miles of view corresponding to each wind, I included all days not absolutely rainy or foggy.

In the tables now given, which sum up the observations for the period, February 1895 to September 15, 1901, I have thought it desirable to include only fine or fair days, that is, days which were either cloudless or only partially clouded, in order to make the conditions with different winds in which haze or clearness occurred better comparable with one another. The disturbing effect of a valley fog, of a rising stratus, and of low clouds, is thus largely eliminated.

Showery days, with fine intervals, have been counted in. The hours of observation were from 11 a.m. to 3 p.m.

Table I. shows the number of instances of fine days with each wind, the total number of miles of view, and the mean distance of view in miles.

TABLE I.—PERIOD, FEBRUARY 4, 1895, TO SEPTEMBER 15, 1901.

Direction.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	Var.
Instances .	96	168	97	48	51	129	164	103	29	34
Miles . .	1454	2333	1496	850	1105	3327	4235	2863	403	393
View in Miles	15·1	13·9	15·4	17·7	21·7	25·7	26·9	27·8	13·9	11·5

From these figures we obtain the following as the order of winds in relation to clearness :—

N.W., W., S.W., S., S.E., E., N., N.E., Calm, Variable.

Table II. gives the distance of view in miles for each wind on fine days, between 11 a.m. and 3 p.m., for the several years :—

TABLE II.

Year.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	Var.
1895 . .	13·07	15·2	17·1	15·4	22	24·1	31·1	22·2	19·8	14·4
1896 . .	(17)	14·7	14	...	...	(36)	(15)	...	...	...
1897 . .	17·3	14·7	14	(20·6)	(22·1)	28·4	26	27·9	10	10·6
1898 . .	(12)	15·6	(10·8)	13·8	(17)	27·7	24·3	(12)	11·3	12
1899 . .	16·7	8·5	14	18	20·1	26·2	28	20	11	11
1900 . .	16·5	12·8	7·7	(16)	20·2	22·4	24·1	25·7	12·5	(12)
1901 to Sept. 15	12·4	15·7	19·9	14·1	23·7	24·8	27·4	26·4	14	13·5

It appears that, for fine days, the order of winds in relation to clearness was as follows (Table III.) for the years 1895, 1897, 1899, 1900, and 1901 to September 15. The few observations made in the intervening years are omitted.

TABLE III.

1895	W.	S.W.	N.W.	S.	Calm	E.	S.E.	N.E.	Var.	N.
1897	S.W.	N.W.	W.	S.	S.E.	N.	N.E.	E.	Var.	Calm
1899	W.	S.W.	S.	N.W.	S.E.	N.	E.	Calm	Var.	N.E.
1900	N.W.	W.	S.W.	S.	N.	S.E.	N.E.	Calm	Var.	E.
1901	W.	N.W.	S.W.	S.	E.	N.E.	S.E.	Calm	Var.	N.

Table IV. gives the number of cases of visibility of 22 miles and more on fine days, and the percentage of such visibilities of the total number of cases of each wind on fine days.

TABLE IV.

Year.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	Var.
1895 . .	1	3	4	1	4	17	17	5	4	1
1897 . .	2	6	3	2	4	16	16	14	...	...
1899 . .	3	0	4	5	2	13	13	10	1	...
1900 . .	4	2	0	0	6	7	16	9	1	...
1901 . .	2	6	7	1	2	9	8	9	1	0
Total .	12	17	18	9	18	61	70	47	7	1
Total cases of Winds	87	135	88	39	49	115	137	99	26	28
Per cent .	13·7	12·6	20·4	23·0	36·7	53·0	51·1	47·5	27·0	...

From the percentages in this table we derive the following order of visibility for each wind on fine days :—

S.W. W. N.W. S. Calm. S.E. E. N. N.E.

The first three points being nearly equal, this order closely corresponds with the general results derived from Table I.

Table V. gives the distance visible on fine days during the warmest

months of the year, from May 1 to September 30, in 1895, 1897, 1899, 1900, and 1901. These periods are better intercomparable than the colder months, but owing to the number of days of each wind being smaller, the results are not of equal value to those for longer periods of each year. The number of South-east winds especially is too small to give a representative figure except in the mean for the series of years.

TABLE V.—VIEW IN MILES ON FINE DAYS IN SUMMER, MAY 1 TO SEPTEMBER 30.

Year.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	Var.
1895 . .	12·3	13·7	17·1	14·2	26·2	23·6	31·8	23	15·3	19·7
1897 . .	16·4	18·4	13·7	27·7	30	30·5	29·4	34·8	6·7	7·5
1899 . .	16·6	10·7	17	20·1	23·5	27·7	32·5	22·9	...	...
1900 . .	13·6	12·7	(7)	...	24·2	24·4	23·4	18	...	15·3
1901 . .	13·7	16·4	20·9	14·6	23·8	24·7	32·2	28·6	11·8	...
Mean * .	15·1	15·6	16·4	19·3	25·3	26·0	29·5	26·6	14·6	11·9

* For the whole number of days taken together.

The order of clearness of the eight directions for these five summers is—

W. N.W. S.W. S. S.E. E. N.E. N. Calm. Variable.

When a very strong wind is blowing or has blown from the South-west or West, there is often a peculiar white haze which largely diminishes the visibility. This, I think, is due to the scattering of minute particles of salt water into the atmosphere from sea-spray, leaving salt particles on evaporation, and does not depend on the ordinary causes of haze. The mileage of view for South-west winds would be distinctly greater without this factor.

As a supplement to these results, I have investigated the relation between the transparency of the air and the directions of lower and upper currents at the hours of observation; these were recorded in my notes, not regularly, but very frequently, during the years 1895-1901.

Table VI. gives the number of instances of each case named during the period, and the corresponding mean extent of view in miles.

TABLE VI.—PREVAILING WIND.

Direction.	Number of Instances.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
(1) Wind and upper clouds the same in direction.	116	19·5	19·3	22·2	16·8	23·7	26·8	24·1	24
(2) Not differing more than $\frac{1}{8}$ of the circle . .	120	8·7	14·5	14	14·6	22·4	20·3	22·8	19·4
(3) Differing more than $\frac{1}{8}$ and not more than $\frac{1}{4}$.	58	13·3	14	9·6	13·6	16·7	28·5	23·2	(16)
(4) Differing more than $\frac{1}{4}$.	95	7·8	10·7	12·6	13·8	17·2	(5·4)	(12)	(30)
(5) Diametrically opposed, or by 15 out of 16 points . . .	41	11·2	10·8	14·3	...	...	...	...	...

From this table we derive a mean for—

(1) of 20 miles.
(2) ,, 17·1 ,,
(3) ,, 16·8 ,,
(4) of 13·6 miles.
(5) ,, 11·8 ,,

It is necessary to observe, however, that these figures give an exaggerated evidence in this respect, that the number of Easterly winds very greatly increase, and the number of Westerly winds very greatly diminish in proportion to the opposition between lower and upper currents, or, otherwise stated, there is a great excess of North-east and East winds, which are the haziest, in the cases of opposing currents, and a great deficiency of Westerly winds, which are the clearest.

Table VII. gives the number of instances of each wind in each of the above classes of cases:—

TABLE VII.

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
(1)	7	3	6	4	10	31	41	15
(2)	6	15	5	9	11	23	26	25
(3)	9	10	12	8	4	10	4	1
(4)	10	26	36	12	4	4	2	1
(5)	4	17	20	1	0	0	1	0

This table gives very strong testimony to the general prevalence of Westerly currents at high levels.

And it must be borne in mind that, in a large number of cases when views were clear, I did not make a note of the direction of upper clouds being the same as that of the surface wind, and that in the great majority of cases of fog or thick haze I was unable to obtain a view of upper clouds, or there were none in the sky, when the direction of the upper current was no doubt very different from that of the lower.

I think, therefore, that on the whole still greater differences would be shown between the mean distances of view with similar and dissimilar winds at the two levels if the observations were extended, and especially if, by daily balloon ascents to 40,000 feet, a complete record could be obtained.

Oppositions of direction between the surface wind and the wind at high levels are not common much below the mean height of cirro-cumulus. Out of a large number of observations of the directions of clouds in the middle air, I find very few cases of a difference of more than a quarter of the circle; in nearly all these cases there was thick haze.

In Table VIII. the mean results of the observations for the two years, 1895 and 1897, including days other than fine (from the *Quarterly Journal* of July 1898), the mean results of the six years for fine days given in Table I. of this paper, the means from Table V., and the mean results from Table VI., are set together for comparison:—

TABLE VIII.

Direction.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Mean for 1895 and 1897	14·5	10·3	14·6	17	23	23·2	26·8	22·7
Mean for fine days, 1895-1901	15·1	13·9	15·4	17·7	21·7	25·7	26·9	27·8
Mean for fine days, May 1 to September 30, 1895-1901	15·1	15·6	16·4	19·3	25·3	26	29·5	26·6
Mean of several classes in Table VI.	(5) 11·8		(4) 13·6	(3) 16·8	(2) 17·1	(1) 22		

The similarity between the curve of transparency, according to wind-direction simply, and the curve according to the agreement of lower and upper currents, is rather striking. Opposition of currents, in fact, takes the place of the North-east wind, and similarity of currents takes the place of the West wind, at the minimum and maximum points respectively.

The following are some of the conclusions derived from this whole series of observations, and from others which cannot be brought into this paper.

Haze and fog are commonly caused by the mixture of currents at different temperatures. These currents may be local or general, high or low. Thick haze or fog not dependent on differing currents is rare, but differing currents frequently come into contact without producing haze or fog, and fairly clear weather under opposite currents is not uncommon.

A fog may generally be taken *ipso facto* as evidence of the existence in the neighbourhood of a conflict of currents, and prevalent fog or haze commonly signifies that a different wind exists at a high level from that on the surface or at a slight elevation.

The production of fog or haze by mixing currents depends chiefly on differences in their temperature.

The rapid increase of haze in the evening, and the slow dissipation of haze under the morning sun, testify to the proximity to their dew-point, even in the dry air of an east wind, of small particles, which have been called atmospheric dust, and it is certain that the hygrometer does not correctly represent the relative humidity affecting a small particle in mid-air.

Particles of salt are hygroscopic, and particles of carbon are excellent radiators, and easily become nuclei for aqueous deposition.

Broadly-extended Westerly winds, with Westerly upper currents, are the clearest, and visibility may reach the highest figures during their prevalence, whether they are dry or nearly saturated.

Easterly and North winds are the haziest, owing to the ordinary upper current from the west being seldom displaced by them, and to the mixture of these masses of air of different temperatures. When, as an exception, East and North winds are clear, it may be presumed, without direct evidence, that the upper current nearly coincides with them in direction. In winter, therefore, unusual clearness in these winds often signifies a long spell of frost.

There are many other cases in which haze or transparency, when we know their causes, may be found of considerable value as an aid to the forecast of weather.

DISCUSSION.

The President (Mr. W. H. DINES) said they would all agree in thanking Mr. Russell for his very interesting paper.

Mr. F. C. BAYARD inquired if all the observations had been taken at the same place, for in a previous paper by the author, if he remembered rightly, some of the observations were made at Bournemouth. He thought that the combination of the two places would hardly give comparable results, as Haslemere would undoubtedly be affected in Easterly winds by London smoke, while Bournemouth would not be so.

Capt. M. W. C. Hepworth said he supposed Mr. Russell meant comparatively high, when he spoke of opposing air currents at high levels. Over the open sea the upper currents of air rarely appeared, by observing the cirrus cloud, to move in the same direction as the lower. In connection with fog at sea he had noticed that a clearing of the atmosphere did not take place permanently until a change of wind occurred; that the formation of clouds overhead presaged the "lifting" of fog, presumably marking the descent of an air current that had been flowing at a higher level. He had also observed on the south-east coast of Africa and elsewhere that the advent of a cyclonic area generally caused great haziness, which became very thick during the passage of the centre of the disturbance; but the weather resumed its normal clearness after it had passed away, when the direction of the surface wind had changed to a south-westerly direction.

Mr. R. H. Curtis said he believed that in Mr. Russell's previous paper on this subject he had based some of his conclusions upon observations made at Richmond, Surrey, and as that place was but a few miles to the westward of London it was easy to understand how an Easterly wind at Richmond should be accompanied by a more or less opaque atmosphere, because of the drift towards it of the London smoke. In the present paper the place of observation had not been stated, and he thought the omission an important one; he also thought it would have added to the value of the observations if the method adopted in making them had been set out. Assuming that they had been made at Haslemere, he thought the distance of that place to the north-west of London was not sufficiently great to place it beyond the reach of the London smoke, which would, of course, be most directly drifted towards it by a North-easterly wind, and therefore one might expect that wind to be accompanied by the most hazy atmosphere. As showing the importance of considering the position of large towns in such an inquiry as this, he might mention that recently he was dealing with some observations made at a place situate from 20 to 30 miles to the eastward of a very smoky district, and he had found that in that case the Westerly wind was the wind which brought with it the haziest atmosphere. As compared with other places similarly situated, except as regards the matter of smoke, its record of sunshine for the year was low, owing to the predominance of Westerly winds, and one curious result of this appeared in a relatively low temperature of the soil at one foot below the surface.

Mr. J. E. Clark (who was unable to be present) sent the following communication, which was read to the meeting:—

"The following notes are based on observations of the West Riding Hills, as recorded from Feversham Terrace, which overlooks the Yorkshire Gentlemen's Cricket Field, in the north suburbs of York.

"When clear there were two distinct lines, namely, the hills near Pateley Bridge, 25 to 30 miles distant, and the second line, consisting of the Whernsides and Buckden Gavel, some 40 miles distant. The height from which they were observed would be some 70 ft. to 80 ft. above sea-level, or about 25 to 30 ft. above the ground.

"Values '1,' '2,' '3,' were assigned according as—

"(1) The 1st line was visible.

"(2) The 1st line was clear.

"(3) Both lines were distinctly seen.

"Short absences were allowed for, but as, until 1896, I was away practically all of July, that month has been omitted. Observations in 1895-96 indicate a decrease for that month compared with June, the actual totals being 23 against 35. Observations ceased with July 1897. August 1883 and 1896 were also blanks. A mean was taken for the former from the years 1883-90,

and for the latter from 1891-95. Subject to these corrections we find the values to be as follows :—

Period.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year. (cor).	Year. (obs.)
Totals.														
1883-90	14	17	42	38	37	32	...	41	40	28	3	0	292	287
1891-97	26	13	72	84	104	80	2 yrs. (23)	83	63	58	18	21	622	597
1883-97	40	30	114	122	141	112	...	124	103	86	21	21	914	884
Means.														
1883-90	1·8	2·1	5·3	4·8	4·6	4·0	...	5·1	5·0	3·5	0·4	0·0	36·5	...
1890-97	3·7	1·9	10·3	12·0	14·9	11·4	(11·2)	11·9	9·0	8·3	2·6	3·0	88·9	...
1883-97	2·7	2·0	7·6	8·1	9·4	7·3	...	8·3	6·9	5·7	1·4	1·4	60·9	...
Actual Years	15	15	15	15	15	15	2	12	14	14	14	14	...	...

"The annual totals, excluding July and allowing for other months not observed, are as follows :—

1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
55	39	45	31	30	30	20	42	64	79	116	103	83	91	(86)

"The monthly table shows a strong maximum in May, the sunniest month during the years in question, and an equally marked minimum in November and December, the latter month having least effective sunshine.

"The annual table shows a steady decrease from 1883 to 1889, followed by a yet more striking rise to 1893. After that there is some decrease, but not strongly marked.

"Actual observations, or records, begin with November 1882, with the value 3, and December 0. Up to 1892 November returns only contributed a further 3, and no record was made in December until that year.

"Again the months January to June, 1883, total up to 46. This total decreased annually to 9 in 1889, and only reached and passed 46 in 1892.

"The writer was absent during 1883 from June 19th to September 10th. After that date, *i.e.* for nearly four months, the hills were seen but twice (October 2nd and 5th) before the end of the year.

"These facts make the coincidence with other phenomena attributed to the Krakatoa eruption significant, to say the least.

"Further, up to 1890 the maximum fell in March, with a secondary in August-September, May being 4·6 to March 5·3. After 1890 the May value averages 14·9 to March 10·3, and August is 11·9 to September, which is 9·0. Does not this imply that, during the earlier period, clearness depended more upon strong winds? This might be due to less condensation occurring on dust particles when the air was in rapid motion."

Capt. D. WILSON-BARKER said that, without having made special observations to verify the fact, he believed that the clearest weather was with Easterly winds where he lived. On the other hand, photographers considered that a longer exposure was necessary with an Easterly wind, which appeared rather to support Mr. Russell's views.

Mr. W. MARRIOTT said that some years ago the late Mr. Alexander Cruickshank took regular observations on the visibility of the atmosphere at Aberdeen, and he communicated the results for the three years 1856-58 to the British Association, when meeting in Aberdeen in 1859. He observed

the hills to the south-west of Aberdeen at 50, 40, 30, 20, 10, and 5 miles distant. The number of days in the year on which these objects were visible was as follows:—50 miles on 94 days, 40 miles on 146 days, 30 miles on 187 days, 20 miles on 238 days, 10 miles on 277 days, 5 miles on 346 days, within 1 mile on 361 days. With reference to Mr. J. E. Clark's observations on visibility at York, he (Mr. Marriott) had plotted on the yearly diagram the amount of cloud at York at 9 a.m., and found that there was somewhat of a resemblance between the two curves, the less amount of cloud corresponding approximately with the visibility. Some years ago he and the late Mr. Abercromby, in their paper on "Popular Weather Prognostics" (*Quarterly Journal*, vol. ix. p. 27), had shown that visibility accompanied wedge-shaped isobars, and also straight isobars, and they had given diagrams illustrative of the conditions under which visibility occurred.

Mr. C. HARDING remarked that great visibility was generally accepted as a sign of the approach of bad weather. It was also a familiar observation that great radiation occurred immediately before a storm or heavy rainfall. This was probably due to the damper nature of the Westerly winds, and to the fact that the dust particles, absorbing so much of this moisture, were too heavy to remain in suspension, thus clearing the atmosphere.

Mr. R. BENTLEY remarked that the Westerly winds blowing direct from the Atlantic were probably clearer than the Easterly winds traversing in their course the great land tracts of Europe.

Dr. H. R. MILL said that it was necessary that the position of the station be clearly stated, so that its relation to the various smoke-producing centres could be seen. He thought that the East winds in crossing the North Sea were probably freed from their dust particles of land origin, although they might acquire particles of salt.

Mr. F. DRUCE inquired if there was any special object in taking the observations between 11 a.m. and 3 p.m. He had noticed in the recent heavy fogs that the greatest density was just before the occurrence of the highest barometer reading. It was important to eliminate the effect of the position of the station, and for testing the influence of London smoke he had suggested, when Mr. Russell read his last paper, that a station to the north-east of London should be established for that purpose. When he took observations himself in Surrey he always found the North and North-east winds were the most opaque.

Dr. J. D. PARKER remarked that his own station at Bennington was situated to the north of London, and that he always found the South and South-east winds were the most dense.

Mr. T. P. NEWMAN stated that on one occasion when he was staying at Dieppe for a few days the weather was sparklingly clear and free from haze during a fresh North-easterly breeze. On his crossing the Channel to Newhaven the same wind prevailed, but there was thick haze, which at Lewes became even more dense. The same wind would therefore seem to have different effects at different places. He asked whether Mr. Russell had chosen the most or least visible time for observation, or the same period regularly each day.

The President (Mr. W. H. DINES) said that he thought the author had not allowed sufficiently for the smoke produced in the neighbourhood of London, at least in so far as his observations at Haslemere were concerned. He (Mr. Dines) lived 17 miles to the south-west of London, and, summer or winter, morning or evening, he required no weathercock to tell him if the wind were between North and East, since these winds always brought an unmistakable yellow haze. It was astonishing what a distance smoke would travel. He had noticed that on the north Yorkshire coast no wind from any westerly point was really clear. This was also true of the mouth of the Tyne, excepting that here the South-east winds were hazy and the North-west clear. In both places

the North-east winds were clear, and there could be no reasonable doubt that the haziness of the Westerly winds was produced by smoke from the coalfields and manufacturing districts inland. The same peculiarity was observable on the west coast of Scotland, which he knew well. The air on this coast was remarkably clear, and mountains 30 miles distant could usually be seen, unless the wind chanced to blow from the neighbourhood of the coalfields around Glasgow. The effect was certainly traceable as far north as Oban, perhaps to Fort William, and as far west and south-west as the Irish coast.

Hon. ROLLO RUSSELL, in reply, said that most of the observations were taken at Haslemere, but many, especially during the winter, at Bournemouth. In his previous papers the place of observation was given, and he was willing to supply the dates and places to this paper, but had come to the conclusion that the results were so much alike over a large extent of country that, allowing for certain effects of position in valley or on hill, the locality was unimportant. He had tried to eliminate the disturbing influence of smoke from London at Haslemere and from the town at Bournemouth. The hours 11 to 3 were chosen as the clearest in the day. The smoke from towns and excess of dust in the air were unimportant on the whole compared with the effects due to general causes. No doubt the effect of a town such as Glasgow or of a manufacturing district ought not to be left out of consideration. A merely temporary or local Easterly breeze in Eastern Scotland produced as strong a haze as a steady and widely-extended wind, and an East wind in France, Italy, and the Mediterranean was likewise accompanied with haze. Frequently, no doubt, the greater dryness of the air over the Continent allowed the air to remain transparent, but relatively the effects were the same as in England. The change from transparency to haziness, and back to transparency again, described as taking place in the passage of a cyclone in the southern part of Africa, seemed to depend on causes like to those which obscure and clear the air during the passage of a cyclone in these islands. The ridge isobars and the last quarter of a storm passing from west to east are clear, owing to the uniformity of the Westerly or North-westerly wind prevailing at low and high levels. He had not observed any unusual radiation before a storm, but no doubt that excessive radiation was owing to the clear sky that often preceded an advancing depression.

Damage by Lightning at Higher Brookland, Devon, June 30, 1901.—At Rousdon, Devon, June 29 was the warmest day of the month, with a temperature of 72° in the shade. Distant thunder was heard at intervals all day. Toward evening the sky over the English Channel became very black, and soon after 8 p.m. the storm came on in earnest. Lightning was frequent from all round the compass, and became more vivid and intense as the night wore on. From 2 to 3 a.m. on the 30th the storm was at its height, and at 2.45 a.m. a remarkably vivid flash of lightning was accompanied by three loud reports, like the discharge of great guns at close quarters, and loud thunder shaking all the buildings round. The rainfall was very heavy, 0·40 in. being registered in about 20 minutes, the total record being 1·25 in. The storm continued till 8 a.m., having lasted about 12 hours.

Hearing that a cottage had been struck by lightning I went to investigate, and found that the cottage was situated at Higher Brookland, near Combpyne, Devon, about two miles nearly due north of Rousdon. The cottage is one of a pair standing near a running stream of water. The chimneys are at either end and are built outside the end walls, running up about 4 feet above the roof and finished with a square chimney-pot. The lightning struck the chimney farthest from the water and demolished it down to the roof, scattering

the bricks in all directions, and cracking the slated roof in several places. It appears to have gone down inside the chimney and entered the bedroom below. The effects of the lightning in this apartment were so curious that I made two sketches (Figs. 1 and 2).

Fig. 1 shows the general arrangement—the iron bedstead (with brass knobs) on which a man and wife were sleeping, two pictures hung on the wall, and a rough table in the corner near the window opposite the bed. On a wooden bracket nailed to the wall stood a common clock, which was going at the time. The lightning entered by a small hole in the wall at A (Fig. 2), and travelled obliquely downward, making a hole of exit at B, where a considerable patch of plaster was knocked off the wall, leaving the wooden laths exposed. There was a fainter upward track from this line, as shown in the figure. Another

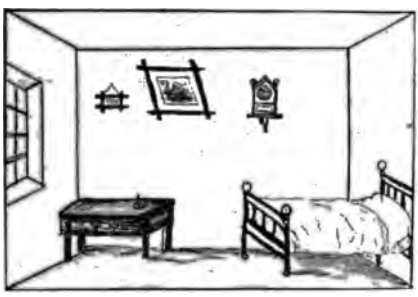


FIG. 1.—Bedroom before Storm.

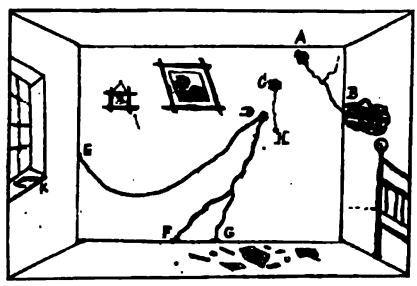


FIG. 2.—Bedroom after Storm.

hole was made in the wall at C immediately behind the clock, which was broken in pieces and fell to the floor as shown. The bracket was also torn from the wall, and the hole at H was made by tearing out a large iron nail with which it was fastened. The nail showed no sign of heating or fusing; neither did the works of the clock. A blackened patch was made on the plaster at D, from which the lightning took a course to the corner of the wall at E, marked by a dark ribbon-like line about $\frac{1}{2}$ inch wide. A part of the side of the clock case was left in the window at K. From the same point at D another course was marked obliquely downwards, dividing into two lines and leaving by small holes at the floor-line at F and G. These tracks on the wall were dark smoky-looking trails, as if made by drawing a lighted candle along the wall, and in places showed a distinct striated structure, such as is often seen in a vacuum tube discharge. The two pictures hanging on the wall were not displaced, neither were the occupants of the bed injured.

In the rooms below the damage was extensive. Passing through the party wall at B, the current went down into the lower room, cracking the wall and blowing the window open outward, breaking several squares of glass. The current from G went down, smashing the glass of a large picture, broke the frame of a smaller picture, and shattered a glass globe on a lamp standing on the table. The current from F knocked off a piece from the mantle-shelf above the fireplace. The current from E went downward and blew the window open outward, shattering the glass as in the window on the other side of the house; these, as well as all other windows in the house, were closed before the storm. There was no range or grate, but a pair of common iron fire-dogs in the fireplace, and no fire was burning when the lightning struck the house. I questioned the man minutely, and ascertained that it was the remarkable flash at 2.45 a.m. which did the damage, and it seemed that the lightning, the three loud reports, and the noise of falling bricks, etc., were all instantaneous, and in his words, "all seemed to have happened in a moment."—C. GROVER.

REMARKABLE PHOSPHORESCENT PHENOMENON OBSERVED IN THE PERSIAN GULF, APRIL 4 AND 9, 1901.

By W. S. HOSEASON, of the S.S. *Kilwa*.

[Read December 18, 1901.]

April 4, lat. 26° 49′ N., long. 56° 31′ E.: time, 8.30 to 8.45 p.m. Barometer, 29·848 ins.; attached thermometer, 85°. I think the correction to the barometer is −·06 in., such being the correction given me by the Indian Meteorological Office in December 1900. Temperature of outside air, dry bulb, 79° F.

Full moon's altitude about 30°, bearing about east-south-east; wind, light to moderate breeze from South-west; clear blue sky, clear horizon, distant land very distinct. Density of salt water taken by salinometer (no hydrometer on board) by Hannon and Buchanan, Glasgow, for temperature 200° 15 ozs. to the gallon; temperature of water, 81° F.: both taken from water drawn well forward, and readings taken when drawn.

Midnight, lat. 26° 18′ N., long. 56° 47′ E.; wind, North-east; barometer, 29·85 ins. (uncorrected); attached thermometer, 79°·5 F.; salt in water, 15½ ozs. to the gallon; temperature, 81°·5 F.

Sea smooth throughout, light ripples on it caused by wind.

At 8.30 p.m., there being no phosphorescence in the water, the sea instantly appeared covered with faint moving phosphorescent light, it not being visible continuously as in ordinary phosphorescent displays, but the sea appearing like a field of corn rippling under a fresh breeze. The light moving upon the water gave this impression. When the phenomenon commenced the ripples were irregular, the water being lit up instantaneously over large and small areas at the same time, and as quickly the light disappeared. In a few minutes the ripples of light grew more regular in direction and appearance, apparently coming from the south-south-east (ahead); and as each ripple of light reached the ship, phosphorescent "droppings" appeared on the surface *close* to the ship, the water then having the appearance of the starry heavens, or as if large handfuls of small pebbles had been thrown into a lake of quiescent phosphorus. As each light-ripple came alongside the "dropping" was observed. The ripples came along very rhythmically, the interval between each being as near as possible a half-second beat of time. In a few minutes we appeared to be reaching the centre of the display, as the light-ripples radiated *from* us, the "dropping" then taking place as the "ripple" began.

Then the ripples came from astern, overtaking and passing the ship as before, until near the end of the phenomenon, when they came from several directions at once, and several times meeting at the ship. The meeting was distinct, and seemed to stop the further progress of each ripple. Gradually the phosphorescence grew less (it was never brilliant, probably owing to the light of the full moon), and finally, at about 8.45 p.m., died away altogether. It appeared suddenly in almost full power, and died away gradually.

The appearance of the light-ripples was often that of a thin vapour (an optical delusion, probably), although driven over the water at an

enormous rate of speed. As, however, it travelled with, against, and at right angles to the wind, it could not have been vapour.

There was nothing in suspension, so far as I could feel (I was about 26 ft. above sea-level), to account for the "droppings." The enormous rate at which the ripples moved may be gauged from the following:—

I could see certainly four miles, and from the time that I first saw any of the "ripples" to the time of appearing to reach the ship was about one second, or perhaps less (I was beating half-seconds), making an apparent speed of 60 miles a minute.

Throughout the display the speed of the ripples remained the same, so far as the eye could judge, and they were visible as far as I could see. The word "ripple" must not be taken to mean a movement of the water, as there was none; but the light moving so rapidly, alternating with darkness—light, dark, light, dark, etc.—made the sea look as though it were moving with a rippling pulsation. The sky was cloudless. I drew a clean bucket of water towards the end of the display, in which I found nothing of any fish spawn, and no unusual taste or smell, but with just a slight greasiness on the surface of the water.

There was no diminution in the force of the wind or alteration of direction during the display.

Others on board assured me that they had seen the same phenomenon twice before up the Gulf—once at Bahrein, and once at the entrance to the Gulf.

Exactly the same phenomenon was observed in lat. 24° 5′ N., 67° 1′ E. on April 9, 1901. Barometer (uncorrected), 29·80 ins.; attached thermometer, 85°; outside temperature, dry bulb, 78° F. Fresh West-south-west breeze; moderate sea raised by the wind, with slight swell from West-south-west; sky overcast; no moon.

Temperature of sea-water during phenomenon, 80° F., 14½ ozs. of salt to the gallon.

Temperature of sea-water at midnight, 80° F., 15 ozs. of salt to the gallon. All observations taken with the same instruments.

At 7.40 p.m., apparent time at ship, the phenomenon was observed as before, and the following extra remarks may be of use:—

It began at 7.40 p.m., and at 7.44 p.m. reached the centre; at 7.46 p.m. reached another centre, and at 7.51 the display ceased.

The direction of the ripples of light coincided at all times with the supposition that there was a centre to the disturbance, and midway between the two centres the ripples were confused, going in different directions, which was accounted for when observing the second centre.

The steamer was steaming 11·4 knots per hour, as against 8 knots on the other occasion, making the distance the ship ran during the phenomenon nearly the same.

The rate at which the ripples travelled was nearly the same, if anything slower on this occasion, and the time between each pair was a little longer—about ninety passed in the minute. The ripples of light were about 50 feet broad, the dark spaces between being a little broader. The "droppings" were bigger on this occasion, as though larger pebbles had been thrown into the pond. I did not see any light on the horizon, a dark band being visible around the display.

Another interesting fact I have noticed is that, correcting the time

of the former occurrence for diff. of long., it will be seen that the times of the displays nearly coincide.

On mentioning this I have been informed that the two former displays mentioned occurred between 6.30 and 8.30 p.m. I also notice that the difference in density of the sea-water, during and after the phenomenon, is the same on each occasion, viz. half an inch of salt to the gallon *less* during the display. On the occasion of this latter display the light was a little brighter, probably owing to there being no moon visible.

The Captain (Captain Whitehead) likens the appearance of the light on the water to a series of rapid flashes of a search-light. That, however, does not apply to the direction of the ripples, which were nearly always parallel to each other.

DISCUSSION.

Capt. A. CARPENTER considered that the paper was more on a zoological, than on a meteorological, subject. Notwithstanding that, it was very interesting. Travellers down the Persian Gulf or through the Gulf of Aden were well aware of the brilliant displays of phosphorescence in those seas. The luminosity was sometimes caused by Salpæ, truncated jellies that formed colonies as much as four feet across; at other times they went singly or in long chains. Then there was the Noctiluca, a small globular jelly that by day looked orange-red and sometimes covered the surface of the Red Sea for miles. By night these same organisms flashed like diamonds in every ripple. Then there were the countless millions of Copepods and other small crustaceans that broke into living fire as the ship's bows ploughed through the water. The "Milky Sea" is a more rare display, and has not been properly accounted for. When this occurs the ship seems to be steaming through a sort of luminous fog in which all sense of distance is lost; sea and sky seem to join, and there is almost as much danger of collision as in a true fog. He thought that the author had possibly mistaken the distance at which he could first see the coming ripples. Most of these small jellies are the free-swimming generative buds of some of the Hydroida, a plant-like zoophyte, frequently taken for a sea-weed. It is a pity that the author did not examine the greasy water surface under a microscope. Off the coast of Madras he (Capt. Carpenter) once found a strong light streaming up from below water at 16 fathoms' depth where there was no phosphorescence on the surface. He thought it might perhaps have been caused by decaying vegetable matter brought down by a river. The emission of phosphorescence seems to be always a momentary impulse from contact or from impact, and Capt. Carpenter thought that, strange as it may seem, the rapid passage of concentric flashes may have been a sort of combined satisfying movement in these tiny organisms, following out some natural law of which we have at present no knowledge. In support of this he called attention to the simultaneous movements of the individuals in the flight of a flock of starlings, to the whirling of flocks of rooks in great circles, and to the sudden madness that may temporarily seize a herd of cattle. The "droppings" close to the ship looked like the sudden turn and retreat of larger organisms taking alarm at the vessel's presence.

Capt. D. WILSON-BARKER agreed with Capt. Carpenter's view that the phenomenon was zoological rather than meteorological. He briefly enumerated the principal phosphorescent-producing organisms (such as *Noctiluca miliaris*, *Pyrocistis prendonoctiluca*, *Ceratium tripis*, and the *Tunicate Pyrosoma*, etc.) in the sea, particularly in the Persian Gulf and the Red Sea. He showed by means of rough sketches on a blackboard how different conditions produced

different appearances and made it difficult to detect the organisms; he also thought it probable that the ripples of light were pulsations similar to those which may be produced in a glass of sea-water containing these organisms, by simply tapping it with the finger.

Dr. H. R. MILL pointed out that a salinometer graduated for use at 200° was of no value for measuring the amount of salt in sea-water at ordinary temperatures.

Capt. M. W. C. HEPWORTH said that the interesting explanations that had been given of phosphorescence did not account for the "pulsations" alluded to by the observer. He was of opinion that these were caused by tide ripplings which the vessel had overtaken in highly phosphorescent water. Ripplings under such conditions would appear as a succession of flashes as the vessel approached, and when she was in the midst of them, what would appear in daylight as a rough sea in miniature would have the appearance of "droppings" in the luminous water at night. Owing to the effect of displacement of water as the vessel moved onward, the tide ripplings would gain energy to overtake her for a time, and the flashes would be repeated from astern.

[In the discussion which followed Mr. Hoseason's paper two of the points touched upon—the mingling of undercurrents with the surface water, and the rapid change in the salinity of the water gauged—are incidentally referred to in a recent issue of *The Geographical Journal* (September 1901, p. 292):—

"The most remarkable feature of Bahrein is the existence of numerous fresh-water springs, on the reefs below high water, and also under the sea. Their origin has not been satisfactorily explained. . . . A possible solution is that the water comes from the Persian mountains, which would require the existence of a synclinical basin under the Gulf with an outcrop of water-bearing strata at this point.

"The head of water at the submarine springs is noticeable; the water will rise through a tube (a hollow bamboo is used by the natives) above the surface of the sea so that vessels may be filled."

This up-welling of the fresh water from below would probably account for some of the features described by Mr. Hoseason.]

Mean Temperature of the Atmosphere and the Causes of Glacial Periods.—Mr. H. N. Dickson read a paper on this subject at the recent Meeting of the British Association, which has been printed *in extenso* in *The Geographical Journal* for November 1901. Starting with the assumption that the secular variations of climate in the past have been due to changes in the mean temperature of the atmosphere, the author pointed out that such changes have probably been associated with large relative alterations in the gradient of temperature between the equator and the poles. But as this difference of temperature is the primary cause of the whole planetary circulation of the atmosphere, the form and intensity of the latter must have varied with it. Thus a lowering of the mean temperature would be accompanied by an increase of the equator-poleward gradient, a rise by a diminution of it, and in the former case the planetary circulation would become more active, and the tropical high-pressure belts would be displaced to lower latitudes. It is suggested that the effect of these changes on the distribution of precipitation, and on the position and directions of the great cyclone tracks, may explain some peculiar features of glacial phenomena.

ON THE MECHANICAL PRINCIPLE OF ATMOSPHERIC CIRCULATION.

By Captain R. A. EDWIN, R.N., F.R.Met.Soc.

(Abstract.)

[Read December 18, 1901.]

The author says: "Anticyclone and cyclone are the terms by which certain kinds of atmospheric circulation have been distinguished," but it does not "appear to be shown conclusively that these are the only arrangements possible, and there is also reason to assume that both cyclonic and anticyclonic wind rotation are not confined to certain pressures and geographical limits."

The author then describes what he considers to be "the probable arrangement and distribution of atmospheric pressure," which may be summarized as follows: —

On both sides of the equatorial belt of low pressure, up to latitude 30° to 50°, is a region occupied by large detached anticyclonic systems, separated from each other by narrow spaces, in which the pressure is the same as that of the equatorial belt. These anticyclonic systems are always varying in size as they travel Eastwards, and their Eastern sides form the North-east and South-east Trade winds, in the northern and southern hemispheres respectively.

Tropical cyclones, he considers, originate near the edges of the equatorial belt. They then move Westwards and polewards, their course curving round to North-east (or South-east in the southern hemisphere), and if they develop sufficient energy they force themselves between the anticyclonic systems into the region of the Westerly winds. These regions of Westerly winds lie on the polar sides of the anticyclonic belts, and extend round the earth and up to latitude 60°. Within them pressure is usually below 30 ins., and the wind direction varies some 45° on either side of West. Polewards, again, of these regions are systems "whose pressures are lower than those of other regions," and whose Westerly winds are in contact with the Westerly winds of the band belts. The author considers that the whole of these systems move Northwards or Southwards with the change in the sun's declination and under his influence.

In the equatorial belt and in that of the West winds, and also at the poles, there are ascensional currents which at certain levels overflow Northwards and Southwards, and supply air to the anticyclonic systems by which they are bounded, and in which down-currents always exist. "But the demands of Life, Land, and Water, for Air are both constant and imperative, and there must, therefore, be continued renewal from beyond the limits of our atmosphere, which, although cold in its uppermost region, is yet warmer than space with whose ether it is in contact."

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

November 20, 1901.

Ordinary Meeting.

WILLIAM HENRY DINES, B.A., President, in the Chair.

Rev. JOHN MACKENZIE BACON, F.R.A.S., Coldash, Newbury ;
JOHN YOUNG BUCHANAN, M.A., F.R.S., F.R.S.E., Christ's College, Cambridge ;
Major HENRY ALFRED CUMMINS, M.D., F.L.S., Nightingale Place, Woolwich ;
FREDERICK HENRY GRINLINTON, F.R.G.S., Assoc.Inst.C.E., Colombo, Ceylon ;
FRANK EDWARD HARDCASTLE, 2 Delal Street, Bombay ;
RAI SAHIB KALI KRISHNA MUKERJU, B.A., Amballa, Punjab, India ;
JAMES SMITH, Pinewood, Crathes, N.B. ; and
JAMES ROBERT TWENTYMAN, Shanghai, China,
were balloted for and duly elected Fellows of the Society.

The following communications were read :—

1. "THE EXPLORATION OF THE ATMOSPHERE AT SEA BY MEANS OF KITES." By A. LAWRENCE ROTCH, M.A., F.R.Met.Soc. (p. 1).

2. "METEOROLOGICAL PHENOMENA IN RELATION TO CHANGES IN THE VERTICAL." By Prof. JOHN MILNE, F.R.S. (p. 9).

December 18, 1901.

Ordinary Meeting.

WILLIAM HENRY DINES, B.A., President, in the Chair.

ARTHUR BROWN, M.Inst.C.E., Guildhall, Nottingham ;
CHARLES HENRY CLARKE, LL.D., 120 Thorold Road, Ilford ;
ALFRED WILLIAM JOHN DEBNAM, Stonehouse, Plymouth ;
EDWARD WILSON DIXON, M.Inst.C.E., 14 Albert Street, Harrogate ;
FREDERIC JOHN DIXON, Assoc.M.Inst.C.E., Ganstead Rise, Harrogate ;
JOSEPH PARKER GREENWOOD, Woodbine Grove, Burnley ;
WILLIAM SMITH JACKSON, 23 Gatefield Road, Sheffield ;
GEORGE BERTRAM DE B. KERSHAW, 16 Bessborough Gardens, S.W. ;
FREDERICK WALTER MAYER, Aldridge, Walsall ;
THOMAS OVERBURY, 6 Well Walk, Cheltenham ;
JOHN BYRNE POWER, M.R.C.P.I., D.P.H., Kingstown, Co. Dublin ;
WILLIAM JAMES PRESS, Barrow Road, Burnham, Somerset ;
ANDREW WARREN, Buckfastleigh, South Devon ;
PHILIP ALFRED WHITTOME, Rothesay Road, Bedford ; and
JOHN THOMSON WILSON, M.D., D.P.H., Bothwell, Lanark,
were balloted for and duly elected Fellows of the Society.

Mr. F. DRUCE and Mr. T. P. NEWMAN were appointed Auditors of the Society's Accounts.

The following communications were read :—

1. "FURTHER OBSERVATIONS AND CONCLUSIONS IN RELATION TO ATMOSPHERIC TRANSPARENCY." By the Hon. F. A. ROLLO RUSSELL, F.R.Met.Soc. (p. 19).

2. "Remarkable Phosphorescent Phenomena observed in the Persian Gulf, April 4 and 9, 1901." By W. S. Hoseason (p. 29).

3. "On the Mechanical Principle of Atmospheric Circulation." By Capt. R. A. Edwin, R.N., F.R.Met.Soc. (p. 33).

Capt. D. Wilson-Barker showed a number of Cloud pictures taken with a Panoram Camera, the special features of which were the extensive area embraced in the picture, and the unusual facility with which the horizontal and vertical appearances of the clouds were reproduced.

CORRESPONDENCE AND NOTES.

Meteorological Office, Rome.—Prof. Luigi Palazzo has been appointed Director of the R. Ufficio Centrale di Meteorologia e Geodinamica, Rome, in succession to Prof. Pietro Tacchini.

Mauritius Meteorological Society.—We have recently received the *Proceedings and Transacions of the Meteorological Society of Mauritius*, 1896-1900. Vol. I. New Series.—As the last volume of the *Transactions* was published in 1864, it may not be out of place to give a short history and information of the work which has been done in this far-away portion of the British Empire.

The Meteorological Society of Mauritius has published six volumes of *Proceedings and Transactions* (viz. in the years 1853, 1855, 1856, 1859, 1861, 1864), which contain reports of meetings and papers read before the Society, together with accounts of hurricanes experienced in the South Indian Ocean; and also the results of Meteorological Observations made in the Colony. Want of funds and other causes led to the *Transactions* being discontinued in 1864; but the reports of meetings have come to hand occasionally in the shape of a *Monthly Notice.*

The Mauritius Meteorological Society owes its present position in a great measure to the devotion and energy of the late Dr. C. Meldrum, who was the principal founder of the Society, and who, for a period of over forty years, filled the position of Honorary Secretary. Under his able direction the work of the Government Observatory grew to its present proportions, and is closely bound up with that of the Society, which consists chiefly of extracting and tabulating observations from ships' logs for future discussion at the Observatory, and generally promoting the interests of meteorological science.

No meeting of the Society appears to have been held between August 2, 1894, and August 21, 1896, when the members of the Society assembled to bid farewell to Dr. Meldrum on his leaving Mauritius.

Mr. T. F. Claxton, who succeeded Dr. Meldrum as Director of the Royal Alfred Observatory, was elected Secretary in place of Dr. Meldrum on November 16, 1896, and since that date the meetings appear to have been held twice a year.

The present volume, which is the first of a new series, was published at Mauritius in 1900, and is edited by Mr. Claxton. It contains twelve papers, two of which only are signed; but it may be assumed that the others are from the pen of Mr. Claxton. The volume also contains an abstract of the Proceedings of the Meetings of the Society held during the years 1896-1900. The papers published in the volume are:—"The Drought of September, October, and November, 1896" (4 pp.); "The Drought of September to December, 1896" (6 pp.); "The Cyclone of February 20, 1896" (13 pp.); "Cyclones in the South Indian Ocean during the Season 1896-1897" (25 pp.); "Cyclones

in the South Indian Ocean during the Season 1897-1898" (42 pp.); "Results of the Actinometric Observations made at the Royal Alfred Observatory from 1887 to 1897" (5 pp.); "The Cyclone of January 1-10, 1899" (9 pp.); "On the Annual Variation of the Meteorological Elements at Mauritius," by A. Walter (5 pp.); "The Cyclone of March 3-9, 1899," by A. Walter (10 pp.); "The Hurricane Season of 1899-1900" (17 pp.); "Registration of Bright Sunshine at the Royal Alfred Observatory, Mauritius" (16 pp.); "The Cape Gales of 1900" (8 pp.).

Hourly Velocity of the Wind at Rousdon.—As is well known, the late Sir Cuthbert E. Peek maintained a well-equipped Observatory at Rousdon, which is a short distance within the eastern boundary of Devonshire, and midway between Lyme Regis and Seaton. The Observatory stands upon a plateau at an elevation of 516 ft. above sea-level, and about a quarter of a mile back from the cliff. Sir C. E. Peek considered the situation to be favourable for the study of atmospheric phenomena generally, and, owing to its elevated and thoroughly exposed position, he believed it to be especially suited for the prosecution of anemometrical experiments. In 1885 a recording large Robinson anemometer of the Kew standard pattern was erected upon the Water Tower,

MEAN HOURLY VELOCITY OF THE WIND, 1896-1900.

MONTH.	A.M.											
	1	2	3	4	5	6	7	8	9	10	11	Noon.
	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
January	11·7	11·6	11·4	11·7	11·6	11·7	11·7	11·8	11·8	11·7	12·7	13·2
February	11·4	11·3	11·5	11·8	11·8	11·6	11·6	11·6	11·8	12·3	12·5	12·8
March	11·5	11·8	11·8	11·9	11·7	11·7	11·8	12·0	12·7	12·8	13·3	13·4
April	10·5	10·2	10·1	10·3	10·2	10·4	10·7	11·0	11·4	11·2	11·5	11·7
May	10·4	10·5	10·6	10·6	10·8	10·9	10·8	11·1	11·4	11·6	11·8	12·0
June	8·5	8·5	8·4	8·3	8·4	8·3	8·8	9·2	9·2	9·1	9·6	9·6
July	8·0	8·0	7·9	7·8	7·8	7·4	7·6	8·0	8·1	8·0	8·3	8·5
August	8·7	9·0	8·7	8·7	8·7	8·6	8·6	9·0	9·4	9·7	9·7	10·1
September	8·7	8·8	8·7	8·4	8·6	8·4	8·6	8·7	8·9	9·7	10·1	10·4
October	10·0	10·2	10·2	10·2	10·4	10·5	10·8	10·7	11·0	11·4	11·8	12·0
November	9·6	10·0	10·2	10·0	10·0	10·4	10·6	10·7	10·7	11·1	11·2	11·4
December	12·8	13·1	13·0	12·8	12·6	12·7	12·8	12·9	13·0	12·8	13·2	13·2
Year	10·2	10·3	10·2	10·2	10·2	10·2	10·4	10·6	10·8	11·0	11·3	11·5

MONTH.	P.M.											
	1	2	3	4	5	6	7	8	9	10	11	Mid-night.
	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
January	13·4	13·2	13·1	12·7	12·3	12·3	12·2	12·2	12·0	12·1	12·0	12·0
February	12·6	12·7	12·3	12·2	11·9	11·4	11·5	11·5	11·6	11·8	11·4	11·4
March	13·6	13·5	13·7	13·4	13·0	12·2	11·6	11·6	11·6	11·5	11·5	11·5
April	12·0	12·2	12·3	12·3	11·9	11·4	10·7	10·3	10·4	10·3	10·3	10·3
May	11·7	11·8	11·5	11·3	11·0	10·7	9·9	9·6	9·8	10·1	10·3	10·5
June	9·7	9·8	9·9	9·9	9·3	8·9	8·6	8·0	8·0	8·3	8·4	8·3
July	8·8	8·7	8·7	8·6	8·1	7·7	7·5	7·2	7·4	7·8	8·0	8·1
August	10·0	10·3	10·4	10·4	9·8	9·1	8·8	8·5	8·4	8·6	8·9	8·6
September	10·4	10·4	10·6	10·4	9·9	9·3	9·0	8·7	8·8	8·8	8·6	8·6
October	11·9	11·4	10·9	10·5	10·1	9·7	9·9	10·2	10·3	10·3	10·3	10·4
November	10·9	11·2	10·9	11·0	10·5	10·5	10·6	10·7	10·5	10·4	10·3	10·0
December	13·4	13·3	12·6	12·4	12·4	12·5	12·6	12·4	12·5	12·6	12·7	12·7
Year	11·5	11·5	11·4	11·3	10·7	10·5	10·2	10·1	10·1	10·2	10·2	10·2

64 ft. above the ground; and in March 1895 a recording Dines' Pressure-Tube anemometer was placed beside it, in order to allow a comparison to be made of the two instruments. In 1898 the Pressure-Tube anemometer was removed to a specially-designed iron tower erected 400 yards south of the Water Tower, the vane being 50 ft. above the ground. The positions of both the towers will be seen from the accompanying illustration.

The volume of *Meteorological Observations* for 1900, in addition to the results for that year, contains tables of average results of the various elements for the

Anemometer Tower at Rousdon. (The Water Tower is shown on the right.)

17 years 1884-1900. There is also a table of the mean hourly velocity of the wind for the 5 years 1896-1900, from the Pressure-Tube anemometer, which we reproduce on p. 36.

Report of the Cowl Committee.—The *Journal of the Sanitary Institute* for October 1901 contains the Report on the work of the Committee appointed by the Sanitary Institute of Great Britain to practically test ventilating exhaust cowls (252 pp.). Many years ago, when the subject of ventilation first began to attract a large amount of public attention, a committee was appointed by the Sanitary Institute for the purpose of testing the efficiency of the various cowls and terminals which were being introduced, in order to give the public some reliable means of judging of their merits. The Committee consisted of Sir Douglas Galton, Mr. W. Eassie, and Mr. Rogers Field; Mr. J. Wallace Peggs was afterwards added.

The Committee soon found that before they could arrive at any measure of the comparative value of the cowls and terminals tested, they must establish some standard for the instruments used for measuring the velocities of the air-currents. A large part of their labour was therefore directed towards establishing a standard value for the reading of anemometers and air-meters. In the course of these experiments, and during the trials of cowls and terminals, so many variable conditions had to be taken into account, certain winds and states of the weather waited for, and so many experiments made, that the members of the Committee, who were busily occupied in other pursuits, found that as they tried to digest the mass of records of experiments, the months were passing into years, and the years into decades, with the work still unfinished; and as one by one the members of the Committee passed away, the bulk of the work fell upon Mr. Field. Although a busy professional man, Mr. Field devoted regularly a portion of his time to the direction of the observations and experiments, and to the consideration and reduction of the records. How much this time must have amounted to in the course of the 24 years that the experiments had been going on, no one knows, but there is no doubt that it was a valuable item, even compared with the £2000 which he personally contributed towards the expenses.

Shortly before Mr. Field's death, when he was in failing health, the records were taken over by the Sanitary Institute. After his death no member of the Committee remained, and at the request of the Council, Mr. W. N. Shaw, of the Meteorological Office, undertook to bring the experiments to a close and to superintend the preparation of the report. So voluminous are the records, that although the tabulation of the results was in an advanced state, and many diagrams had already been plotted for the report, it has taken more than twelve months for the two assistants who were in charge of the work at the time of Mr. Field's death to complete the report for issue, under Mr. Shaw's superintendence.

It is greatly to be regretted that the Committee had not discussed the data, as Mr. Shaw has found it impossible to formulate any general conclusions.

The Report is divided into five parts. Part III. is devoted to the determination of wind velocities, and describes the steps taken to ascertain the factors necessary for reducing the readings of the anemometers employed.

Deaths and Fires caused by Lightning in Hungary.—The Kön. Ung. Reichsanstalt für Meteorologie und Erdmagnetismus, Budapest, has published an elaborate report by Herr Ladislaus von Szalay on damage by lightning in Hungary in the period 1890-1900. During the four years 1897-1900, the total number of persons killed by lightning was 601, or a yearly mean of 150. This is equal to 10 in one million. In the eleven years 1890-1900, there were 3406 fires caused by lightning, which gives a yearly mean of 309.

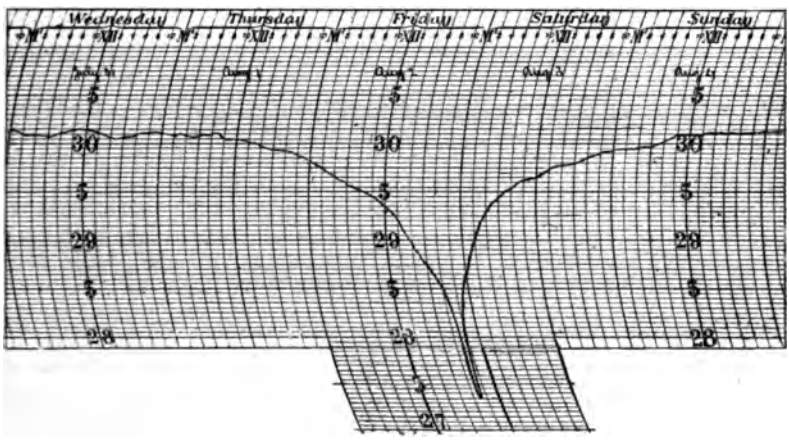
Registration of Bright Sunshine at the Royal Alfred Observatory, Mauritius.—Mr. Claxton contributes a paper on this subject to the recently issued first volume of the new series of *Proceedings and Transactions of the Meteorological Society of Mauritius*, in which he gives the mean amount of sunshine for each hour during which the sun was above the horizon for every month of the year, and also the percentage of these observed amounts to the greatest possible amounts. The means are from 13 years' observations, 1887-1899.

As one result of his discussion, Mr. Claxton finds "a gradual increase of sunshine at the rate of nearly ½ per cent per annum, with, however, no corresponding decrease in the amount of cloud"; and he suggests that this increase may be due to a gradual change in the condition of the surface of the lens, owing to which less of the sun's heat falling upon it is reflected back, and a correspondingly increased amount is transmitted through to the card, or possibly increasing accuracy in measurement (with longer practice) of the observer.

The paper also contains a comparison of the observations of bright sunshine at Mauritius with those made at the Greenwich Observatory. The value of such a comparison is, however, somewhat restricted, because the record of sunshine at Greenwich is necessarily very much affected by the proximity of the Observatory to the smokiest portion of the Metropolitan area; in addition to which it should be remembered that during the period covered by the comparison many of the surrounding districts which used to be more or less rural have become decidedly urban in character.

Barograph Trace during Typhoon, August 2-3, 1901.—By the courtesy of Capt. E. R. Taylor we are permitted to reproduce in the accompanying illustration, one of the most interesting and remarkable barograph traces which we have ever seen.

The following remarks are extracted from a letter sent by a friend in Hong-Kong to Capt. Taylor:—"The lower part of the curve is plotted from readings



Barograph Trace during Typhoon, August 2-3, 1901.

of a mercurial barometer, corrected for index error of the barograph. The instruments were on board one of Jardine's steamers, the *Laisang*, which left this port for Japan on July 30, 1901, and she encountered the typhoon somewhere to the northward of the Formosa Channel, in about lat. 25° N., long. 122° E., or thereabouts."

The fall and rise of the barometer were most rapid, the range being no less than 2 inches in 8 hours.

The chart shows the minimum reading to have been as low as 27·35 ins. at 9 p.m. on August 2. Such a low barometer reading has rarely been recorded. It was, however, exceeded on the following occasions:—

27·33 ins., February 5, 1870. On board H.M.S. *Tarifa*, 500 miles west of Ireland.

27·332 ins., January 26, 1884. Ochtertyre, near Crieff, Scotland. (*Quarterly Journal Roy. Met. Soc.*, vol. x. p. 114.)

27·135 ins., September 22, 1885. False Point, Orissa, India. (*Nature*, vol. xxxv. p. 344.)

27·38 ins., December 8, 1886. Belfast; probably about 27·28 ins. over the north of Ireland. (*Quarterly Journal Roy. Met. Soc.*, vol. xiii. p. 211.)

Wind Force in Tornadoes.—A correspondent asks: "Has any competent observer ever been able to make any estimate which you think would be at all near the truth of what the speed of the wind is in the funnel of a violent tornado?"

The following reply by the Chief of Bureau will be of general interest:—

Prof. F. H. Bigelow has published on page 633 International Cloud Report, vol. ii., *Report Chief of Bureau* 1898-99, the results of his computation on the great water-spout seen off Cottage City, Mass., August 19, 1896. He gives the following additional facts:—This large tornado tube or water-spout over the ocean was seen from several localities, and the direction noted, so that it was easy to place its position on the map with much exactness. At the same time a series of large pictures were photographed by Mr. Chamberlain of Cottage City, showing the spout in several positions relative to the landscape in the foreground. Prof. Bigelow visited the place and made a suitable survey of the distances, so that the scale of the photograph was found, and from this the dimensions of the tube and the height of the cloud. By means of the proper formula the following dimensions in feet and velocity in miles per hour for the different components were obtained:—

Height above sea level.	Diameter of tube.	Radical velocity outward.	Rotational velocity.	Vertical velocity upward.
feet.	feet.	miles.	miles.	miles.
4200	...	...	...	...
4193	3402	7·0	14·1	0·04
3901	506	1·0	94·4	2·50
3599	400	0·6	119·5	3·90
3301	290	0·6	164·0	7·40
2999	250	0·5	189·0	9·90
2398	204	0·4	233·0	14·90
1802	178	0·4	268·0	19·80
1499	168	0·3	284·0	22·20
1201	158	0·3	300·0	24·70
601	144	0·3	328·0	29·60
479	144	0·3	333·0	29·70
0	134	0·3	354·0	34·60

A more thorough study of the data shows that the lower portion of the vortex tube is enlarged over these diameters on account of the friction due to disturbing the water, to the raising of the spray to a height of 500 feet when it is cast out of the tube, and to the indraught of air required to supply the vortex. The effect of this is to increase the size of the tube at the ocean to about 200 feet, and to reduce the rotating velocity to about 300 miles per hour, and the vertical internal draught to about 30 miles per hour. These dimensions and velocities characterise the largest tornado tubes, and together with the fall of

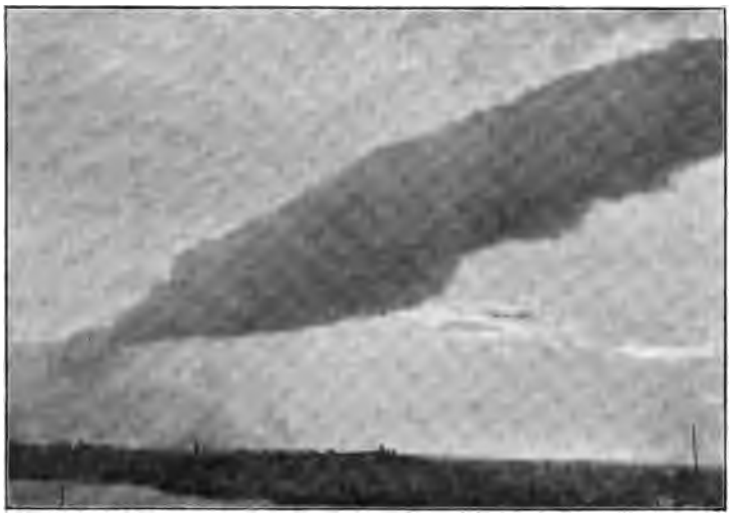
internal pressure by the amount of 3 or 4 inches, they readily cause the destructive effects noted so conspicuously at Louisville, Ky., and St. Louis, Mo., in recent years.—*U.S. Monthly Weather Review*, September 1901.

Observations of the Edinburgh Rock Thermometers.—A set of thermometers buried in the rock were established at the Royal Observatory, Calton Hill, Edinburgh, at the expense of the British Association in 1837. Complete tables of the whole of the observations made with these thermometers during the 40 years 1837-76 were published in the *Edinburgh Astronomical Observations*. By the act of a mad Portuguese sailor the thermometers were destroyed in September 1876. A new set of thermometers were placed in position, June 1879, and the observations from October 1879 to April 1888 were communicated by the late Prof. Piazzi Smyth to the Royal Society of Edinburgh. Mr. T. Heath has now communicated the observations from May 1888 to December 1899 (*Trans. Roy. Soc. Edin.*, vol. xl. pt. i. No. 8).

The following are the monthly mean temperatures at the various depths in the rock for the 20 years 1880-99 :—

	20·9 ft.	11·1 ft.	5·0 ft.	3·0 ft.
	°	°	°	°
January	47·1	45·8	42·1	40·1
February	46·8	44·6	40·9	39·5
March	46·3	43·8	40·5	39·4
April	45·9	43·3	41·2	40·7
May	45·6	43·5	43·2	43·9
June	45·4	44·4	46·4	48·0
July	45·4	45·9	49·5	51·6
August	45·7	47·3	51·2	52·8
September	46·2	48·4	51·2	52·3
October	46·7	48·7	49·8	49·4
November	47·1	48·1	47·0	45·5
December	47·3	47·3	44·4	42·5
Year	46·3	45·9	45.6	45·5

Cloud Photograph.—Mr. P. C. Trebeck of Sydney, New South Wales, has



Cloud during South-west Squall at Sydney, New South Wales, January 1896.

sent us a photograph of a remarkable cloud which he took in January 1896, at sundown, after a very hot day. This is reproduced in the accompanying

illustration. The cloud occurred during one of the South-west squalls, which are accompanied by thunderstorms. As the cloud passed overhead it struck the Admiral's flagstaff about 200 yards from Mr. Trebeck's house. The building on the hill in the middle of the picture is the Sydney Observatory.

Cyclonic Storms in the Bay of Bengal.—Mr. J. Eliot has recently published a second edition of his *Handbook of Cyclonic Storms in the Bay of Bengal, for the use of Sailors.* The first edition was published in 1890. The information has, so far as possible, been brought up to date. The following is a brief summary of what is known from the experience of past years accumulated by the India and Bengal Meteorological Departments of the distribution of storms in the Bay of Bengal, month by month, during the year.

January, February, and March.—Cyclones or cyclonic storms are almost unknown in the Bay in these months, and only occur under very exceptional circumstances and at very distant intervals.

April.—Cyclonic storms are of comparatively rare occurrence. They form either in the south of the Bay or in the Andaman Sea. Those which form in the Bay proper are generated to the west of the Nicobars or Andamans, and march (in at least three cases out of four) in a west or west-north-west direction to the Ceylon or Coromandel coast. Those which originate in the Andaman Sea march northward to the Lower Pegu coast. Storms are somewhat less probable in this month in the Andaman Sea than in the Bay of Bengal.

May.—Cyclonic storms are of comparatively frequent occurrence (about two every three years). If they originate in the first fortnight of the month, the chances are about three or four to one they will march in a westerly direction to the Coromandel coast; but if during the latter half of the month, the chances are three or four to one they will march northwards to the head of the Bay. It is also about an even chance that a storm forming in this month will be of great intensity (*i.e.* a cyclone).

June.—Cyclonic storms are of frequent occurrence in the north of the Bay. They usually form to the north of lat. 19° N., or quite at the head of the Bay. One or two such storms may be expected every year. It is an even chance whether they pass in some northerly direction into Bengal or in some westerly direction across Orissa. Their chief feature is the strong Westerly or South-westerly winds or gales in their southern quadrants. It should also be noted that two out of three advance across the north-west angle of the Bay immediately to the south of the entrance to the Hooghly, and hence they are very trying to shipping leaving the Hooghly at such times.

July.—In July storms only occur in the north of the Bay. They are of comparatively frequent occurrence, an average of two or three occurring in every year. They usually march in a west or north-north-west direction across the north-west angle of the Bay to the Orissa coast. The chances that a storm forming at this time will march in that direction are about ten to one. These storms are frequently feeble, but in about one case out of two they give rise to strong Westerly and South-westerly gales at the head of the Bay, in which the force of the wind exceeds 8. As they almost invariably cross the north-west angle of the Bay, and advance across the track of vessels leaving the Hooghly, outward-bound vessels, unless fully prepared to encounter a severe storm of this kind, should not leave the river Hooghly when the storm signals are hoisted, and should remain in the river until the lowering of the signals.

August.—Cyclonic storms are almost of as frequent occurrence as in July. Five out of every six form to the north of lat. 19° N. The chief feature of the storms of August is the occurrence of strong Westerly and South-westerly gales at the head of the Bay, and the shift of wind is rarely large enough

to indicate their cyclonic character, except in the north-west angle of the Bay. The storms occasionally advance northwards across the Bengal coast, but most frequently in a west or west-north-west direction across the Orissa or Ganjam coast. The chances, based on previous experience, that a storm which forms in the month will advance in a westerly or west-north-westerly direction are four to one, and that it will advance north into Bengal are one to four. As the majority of these storms advance across the track of vessels leaving the Hooghly, captains of vessels about to proceed to sea from Calcutta when the signals are hoisted should, unless they are prepared to encounter strong winds and a very heavy sea, remain in the river until the storm has advanced landwards.

September.—Cyclonic storms are about as frequent during September as in July and August, an average of two occurring every year. These cyclonic storms however, form, as a rule, farther south than in the previous two months, but usually to the north of lat. 17° N. The chances are four to one that the centre of a storm which forms in September will advance in a westerly direction to the north-west coast of the Bay between Balasore and Cocanada. About one storm out of five advances in a northerly direction into Bengal. The great majority of these storms are of small intensity, and resemble the storms of July and August in general character and in the strength of the Westerly and South-westerly winds (as compared with the North-easterly and Northerly winds). Under exceptional conditions, the chief of which appears to be the earlier retreat of the South-west Monsoon current than usual from Northern India, these storms are of great intensity and violence, and accompanied with hurricane winds. Hence cyclones are of very occasional occurrence in September, and are most probable in the last fortnight. They form in the centre of the Bay, and the chances are about equal that they will advance in a north-west direction to the West Bengal or Orissa coast, or in a westerly direction to the coast of the Circars.

October.—Cyclonic storms occur slightly less frequently in October than during any of the four preceding months (an average of about one yearly). They are of rare occurrence in the Andaman Sea, and rarely, if ever, form to the north of lat. 20° N. They may originate in any other part of the Bay, but form most frequently in the centre of the Bay between the Andamans and the coast of the Circars and the North Coromandel coast. If a storm forms in this month, the chances are probably about one to two that it will develop into a severe cyclone. The chances are about even that if a storm is generated in this month it will advance westwards to the coast of the Circars, and if it does so, the chances are also about even that it is a feeble or a severe storm, or in other words, a cyclonic storm or a cyclone. The chances are about one to three that if a storm forms it will advance northwards to Bengal or Orissa, and if it does, the chances that it will be a severe storm or a cyclone are at least two to one. The chances that if a storm forms it will advance to the Madras coast south of Gopalpur are also about one to two, but if it does, the chances that it will be a severe storm are probably about even.

November.—Cyclones may form in any part of the Bay and Andaman Sea to the south of lat. 16° N. Three out of four storms which originate in this month form in or to the south of lat. 12° N. At least one storm may be expected every year in this month. The chances that a storm will be a cyclone are about two to one. If a storm forms, the chances that it will advance to the Coromandel coast are even. About one storm out of four that form advances to the coast of East Bengal or of Arakan. The part of the Bay which is most free from cyclonic storms in this month is the north-west angle of the Bay and the coast from Sangor Island to Vizagapatam. On the other hand, the north-east

coast of the Bay is more liable to cyclones in this month than in any other month of the year.

December.—Storms are of comparatively rare occurrence in this month, and only two storms are known to have formed in the Bay during the present century after the 15th of the month. No storm has been known to form in the Andaman Sea in this month. Storms occasionally form in the south or south-west of the Bay of Bengal between the Ceylon coast and Andamans. The chances are nearly two to one that, if a storm occur, it will be a violent cyclone. It is almost a certainty that a storm which forms will advance in a west-north-west direction to the Coromandel coast between Madras and Negapatam. Hence they are chiefly dangerous in the area between the East Ceylon coast and the Coromandel coast.

RECENT PUBLICATIONS.

Evolution of the Thermometer, 1592-1743. By HENRY CARRINGTON BOLTON. 8vo. 98 pp. 1900. The Chemical Publishing Co., Easton, Pa., U.S.A.

This is a very neatly got-up book, and gives an interesting history of the thermometer. The work is arranged in five chapters, viz.—(1) The Open Air-Thermometer of Galileo; (2) Thermoscopes of the Accademia del Cimento; (3) Attempts to obtain a Scale, from Boyle to Newton; (4) Fahrenheit and the First Reliable Thermometer; and (5) Thermometers of Réaumur, Celsius, and others. There is appended a Table of 35 Thermometer Scales, and also a chronological epitome and a list of authorities. The following is the chronological epitome:—

1595. Open air-thermoscope invented by Galileo.
1611. Sanctorius applies Galileo's instrument to the diagnosis of fevers.
1611. Telioux' thermoscope.
1617. The word "thermoscope" used by Giuseppe Bianconi.
1624. The word "thermometer" used by Leurechon.
1632. Water-thermoscope invented by Jean Rey.
1641. Sealed alcohol thermometers of Ferdinand II.
1643. Kircher's thermoscopes.
1651. Casper Ens originates the Drebbel myth.
1657. Differential thermometer of Caspar Schott.
1660. Giant thermometer of De Guericke, and self-registering thermometer.
1661. Fabri makes a scale by dividing the interval between the temperature of snow and of midsummer heat.
1664. Freezing-point of water taken as a fixed point on scale by Robert Hooke.
1665 Boyle uses aniseed oil to get fixed point on scale.
1667. Florentine thermometers described in the "Saggi."
1670. Paris thermometer.
1688. Dalencé publishes his "Traitté" and proposes divers scales.
1694. Renaldini proposes freezing-point and boiling-point of water as fixed points in scale.
1701. Sir Isaac Newton's linseed oil thermometer.
1702. Amontons' researches.
1709. Fahrenheit's alcohol thermometers.
1714. Fahrenheit's mercury thermometers.
1727. Fowler's thermometers,
1730. Réaumur's thermometers.
1733. De Lisle's thermometer.
1740. Scale of Du Crest.
1742. Scale of Celsius.
1743. Christin reverses the scale of Celsius and thereby establishes the "Centigrade" scale.

Lehrbuch der Meteorologie. Von Dr. JULIUS HANN. Parts IV. and V. 8vo. Leipzig. Chr. Herm. Tauchnitz. 1901.

Book IV. is entirely devoted to air motion, and it occupies more than 100 pages. It commences with a notice of various anemometers, with a brief notice of the relation of velocity to pressure, on which Dr. Hann observes that no satisfactory theory has been proposed. He also remarks that no agreement exists as to the mode of discussion of the various records. As regards the increase in velocity with altitude above the earth, the recent results obtained by balloons and kites are summarised in considerable detail, and also the influence of the contour of the ground on the motion of the wind.

Chapter II. deals with the daily and yearly variation of wind as to velocity and direction. We find the well-known principle that at low-lying stations the wind is stronger by day than by night, whereas at mountain stations the reverse appears. The question then arises, at what level does this reverse in the diurnal period take place? The Eiffel Tower gives the best evidence on this point, inasmuch as at the summit the daily period exactly resembles that on mountain tops; and Dr. Hann expresses the view that the low-level period does not extend to the strata above 100 metres. For the explanation of these phenomena we are referred to the utterances of Espy in America and Köppen at Hamburg.

We next deal with the diurnal period of wind direction, with diagrams and tables of the results for various stations.

We now come to the origination of air movements. Hann shows how the old idea, strongly supported by Dove, that the air rises in a column over a heated area is simply disproved by the fact that as temperature rises at the earth's surface, the pressure *increases* in the upper strata. This is evidenced by the fact that at mountain stations the mean barometer is always higher in summer than in winter, whereas on the plains the reverse is the fact. If, however, the earth's surface is unevenly heated the equilibrium of the atmosphere is at once disturbed. The couches of equal pressure rise over the heated districts, and sink over the cooler ones. This is therefore the broad principle of the origin of wind. Dr. Hann mentions at the end the disturbances of the atmosphere owing to lateral expansion, which have been dealt with by Laughton, F. Chambers, and Blanford, an idea with which Kant disagreed. This whole reasoning is then illustrated by diagrams, and then we deal with the relations between the differences of pressure and the velocity of wind, which brings us to the subject of gradients.

Section IV. treats of the influence of the earth's rotation on atmospheric motion, and in the first instance of Hadley's principle, and then of the extension of this principle to all azimuths, as was proved by Foucault's pendulum experiments. On all this question Dr. Hann refers us to Sprung's *Lehrbuch* and to papers in the *Zeitschrift.*

The concluding section of this chapter deals with cyclonic and anticyclonic circulations. A very interesting note gives the history of Buys Ballot's Law, and the earlier intimations of it by Webster in 1834 and Adolf Erman in 1853.

We now come to Chapter IV., the application of the general principles established in the preceding pages to the explanation of local wind systems, such as land and sea breezes, and hill and valley winds. A diagram at p. 431 of five days' curves of barograph, thermograph, and wind, distinguishing land and sea breezes, from Goree on the coast of Senegambia, is very striking. As regards mountain and valley winds, Dr. Hann shows that Sir R. Strachey was the first to introduce the principle of the disturbance of the couches of equal pressure to explain the phenomena of mountain and valley winds, the general tendency being for a valley wind to blow towards the mountains by day and the reverse action to take place by night. This, *inter alia*, shows how the mountain

tops clear at night, owing to the descending current forcing down the vapour stratum, which rises again in the daytime and produces rain or even thunder-storms in the afternoons.

Chapters V. and VI. treat of the Monsoons, which are of course described as land and sea breezes, with a six-monthly instead of a daily period, and Dr. Hann traces these in other parts of the world besides the Monsoon region of the Indian Ocean, as, for instance, over the Caspian, where Rykatcheff has given diagrams of their presence. This is followed up by some particulars as to the existing differences of pressure and the consequent gradients which cause the flow of air. These are separately given for the two Monsoons of Hindostan.

This is followed by an account of the general circulation over the whole globe, illustrated by large wind charts. We then have an account of the upper currents as far as these are recorded by observation, with quotations from Toynbee (Square III.) and from von Buch at Teneriffe, and above all with the account of the Krakatoa dust.

The general theory of air circulation between the equator and the pole is next dealt with. First are mentioned Halley and Hadley, and finally Ferrel. Then follows an account of the attempts made to draw pressure charts of the globe for a stratum lying at a considerable level above the earth's surface, showing how the gradients are produced. The explanation of the low Antarctic pressure given independently by Ferrel and Murphy, which attributes the force of the "brave West winds" to the centrifugal force of the Westerly winds in high latitudes round the pole, while the views of Max Möller, Ekholm, and Teisserenc de Bort on these theories of circulation are given at considerable length.

The section on atmospheric circulation is closed with a brief résumé of the reasoning of W. von Siemens and Max Möller on the limits of applicability of the principle of conservation of areas, and this is followed by a notice of the yearly period of this circulation, and the differences between the Northern and Southern hemispheres in this respect.

We now come to Book V., the disturbances of the atmosphere, and firstly the weather. This leads off with an account of Dove's wind-roses for the different meteorological elements. The first person who appears to have attempted to draw weather charts for a definite epoch was H. W. Brandes in 1820.

Section II. deals with the phenomena of depressions in general, and this is treated at considerable length. As a first conclusion it is pointed out that the angle made by the wind with the direction of the gradient is least on the eastern and southern sides and greatest on the western and northern, and the figures for duration given by different authors for the eight points are reproduced at p. 497.

We next come to the direction and velocity of motion of the depressions, and some instances of extreme velocities are cited. One of the greatest was that of the storm of Sunday, March 12, 1876, which wrought such havoc in the Midlands.

Dr. Hann then goes on to describe the distribution of cloud and rain in depressions. Then comes the consideration of the changes in air motion with altitude, and it is shown that the efflux from depressions is most active in front. The facts are taken from the series of international cloud observations.

This is followed by a notice of anticyclones, which are analysed in the same way as the depressions.

We then come to the distribution of the meteorological elements in the vicinity of barometrical maxima and minima, subjects which have been specially studied by Hildebrandsson, Brounow, and van Bebber.

We finally come to the vertical distribution of temperature in the maxima

and minima, and this leads to the discussion of the inclination of the cyclone axes.

The third chapter is devoted to tropical cyclones, of which so copious a literature exists, that we need only say that the *Lehrbuch* contains a careful résumé.

This is followed by a chapter on the various theories as to atmospheric cyclones and the causes which produce them, to which subject Loomis, Mohn, Sprung, Clement Ley and Whipple have severally made contributions of more or less value.

The section on the origin of tropical cyclones is very interesting, and it is clearly shown that the copious rain which accompanies them is not their cause. The enormous rain at Cherrapunji does not make the barometer fall; on the contrary, the barometer rises during the continuance of the rain.

The origin of barometrical minima and maxima outside the tropics. Dr. Hann maintains that the former are much more complicated in their genesis, and that we are still far from a satisfactory explanation of them. He maintains that in general the maxima have a dynamical origin, and the chapter closes with a long quotation from Bigelow's *Report of Weather Bureau* for 1898-99. Abercromby's diagram of fundamental types of isobars is then reproduced and explained in detail.

The next chapter deals with the special cyclonic and anticyclonic winds of mountain regions, the Föhn, the Bora, and the Mistral. The Föhn is a very warm and dry current of air which appears in certain valleys, and is always related to some barometrical depression in the neighbourhood. It is observed not only in Switzerland, but in many other parts, as in Greenland and New Zealand. It owes its warmth and dryness to the fact of its descent, which raises its temperature, owing to compression. It sometimes blows as a serious storm. The Bora, on the other hand, is an anticyclonic wind, and it descends from the cold tablelands near the coast at Noworossisk on the Caspian. The Bora is so cold that it lashes the sea surface into spray, which freezes and not uncommonly sinks ships at anchor from the weight of ice washed on the sides. The Mistral is similar to the Bora in its origin.

Dr. Hann then gives an account of van Bebber's maps of storm tracks over Western Europe.

We now come to types of weather, and the tendency of storms to follow each other along similar tracks, and various rules from various authors are given, with numerical tables of the probability of occurrence of, say, warm or cold winters, after certain characters of the preceding summers.

The connection between the surface temperature of the North Atlantic, the so-called Gulf Stream, and the weather of Europe, as shown by the researches of Petterson and H. N. Dickson, is next dealt with, and finally the long period-cycles of weather, such as those insisted on by Dr. Brückner, who has endeavoured to show a 35-year period in the level of the Caspian, while E. Richter has found a period of the same duration in the advance and retrogression of glaciers in Switzerland.

The next subject is thunderstorms, and first the actual phenomena of the storms, the lightning, thunder, and St. Elmo's fire, are described. Then comes the account of the actual structure of the thunderstorm cloud, and of the modification which it undergoes when the electrical discharge has occurred. Dr. Hann cites various evidence as to the extreme rarity of the observation of thunderstorms *below* mountain summits.

Attempts have been made by Klossowsky and others to make maps of thunderstorm frequency, but as a rule this frequency diminishes from the equator to the pole. Dr. Hann remarks that a single thunderstorm of the Southern Alps will exhibit more flashes of lightning than all the storms of

twenty years in Iceland and the Faroes. Certain figures of great interest are given as to the different velocities of thunderstorms, as to their season and their direction of motion.

The period at which thunderstorms occur is treated at some length, and firstly the yearly period. At most continental stations the maximum falls in summer, but in Iceland and the Faroes in winter, and an interesting table is given, showing that the annual period has not materially changed during the last century. The figures are for the intervals 1760-1810 and 1849-1891. In Southern Russia the storms are more frequent by night than by day. In general they are most frequent from 2 to 4 p.m., and the probability of a storm is over tenfold more in the afternoon than in the morning. At sea it is also more common to have thunderstorms at night than by day. We have then a notice of a lunar, a 26-day, and a sunspot period of the storms.

The origin of the storms is first discussed, and then the two classes of heat thunderstorms and cyclonic thunderstorms are specially treated.

This brings us to the advance of thunderstorms over the country, especially of thunderstorm squalls. It is clearly ascertained that the velocity of the wind in the squall is greater than that of the storm itself.

Thunderstorms are followed by the subject of hail, and firstly of its distribution, seasonal and geographical. It is pointed out that most of the enormous masses reported to have fallen owe their origin to regelation. As to the origin of hailstones, Dr. Hann cites the extremely low temperatures recorded by balloon observations at really high levels, like the experience of $-10°$C. at a level of 6000 metres by MM. Barral and Bixio, July 27, 1850.

We now come to the last section of the work, the subject of waterspouts and so-called tornadoes, and of atmospheric electricity. The much greater frequency of the waterspout phenomena at sea is explained by the greatly diminished friction over the water surface, which allows of the development of rotary motion. The diagrams given by Davis of the relation of tornadoes to cyclones and also to the distribution of temperature are reproduced, and so are also Finley's illustrations of the Delphos tornado in four stages of its development.

A very brief sketch of the more modern views of atmospheric electricity closes the book.

An appendix is given relating to some of the most important mathematico-physical theories in meteorology, which we shall simply enumerate:—

1. On the calculation of periodical phenomena; 2. The range of temperature in the earth; 3. The range of temperature in the atmosphere; 4. The range of temperature at night, and the radiation co-efficients of atmospherical air; 5. The vertical distribution of pressure in its relation to temperature and humidity; and 6. Barometrical mountain surveying.

We can only say, in conclusion, that the work of which we have attempted to give a résumé, which is only too imperfect, is destined for many years to come to be the ultimate reference for all facts connected with the science of meteorology.

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. July—November 1901. 4to.

The principal articles are:—"Die Erscheinungen der atmosphärischen Elektricität vom Standpunkte der Ionentheorie aus betrachtet": von Dr. H. Ebert (26 pp.). This is an elaborate discussion of the ionic theory of electricity. The author lays down the following five positions:—(1) The more intense the solar radiation, the greater in general is the radiation of the observed potential; (2) The ions which are generated at great heights in the atmosphere remain for a certain time in the layer of atmosphere in which they are formed, and take part in its motions; (3) Dust, and especially aqueous vapour, interferes with

the movements of the ions, and so reduces the conductivity of the air; (4) Negative ions have a greater velocity motion than positive; (5) Gas ions form nuclei for condensation, and thereby facilitate the precipitation of vapour in the form of fog or cloud from saturated air. The negative ions are more active in this respect than the positive. In the August number Dr. Ebert gives an account of three balloon ascents made with the object of electrical experiments, and with full descriptions of the special apparatus provided in each case. He gives the following summary of his results: (1) Experiments on atmospheric electricity can be carried out in a free balloon, by the use of the method lately proposed by Elster and Geitel, with sufficient accuracy, and without interfering with the usual meteorological observations. (2) With increase of altitude there is an indisputable increase of the velocity of leakage of electricity, independent of the unipolar action of the earth, which, as is well known, disturbs the results obtained on mountain ascents. (3) The lower atmospheric strata, up to the level of 3000 metres, exhibit a similar property to those of the strata close to the ground, and to those in the free air, in so far as that the negative changes show greater leakage than the positive. (4) At higher levels, owing to the increase in the absolute number of ions, the unipolar conductivity seems to equilibrate itself more and more, so that the leakage of the two kinds of electricity is the same. (5) The increase of conductivity with height does not increase uniformly in such a way that we might hope to propose a simple formula with few constants which would represent this increase for all levels. It is rather spasmodic; the special physical condition of the air strata in which the observer finds himself exerts a decided influence on the phenomena. (6) In clear, dry air the coefficient of leakage at the upper levels is great, just as at the ground level. In the same degree in which the moisture increases, and especially when this is near its point of condensation, or is actually in the form of cloud particles, the velocity of loss of electricity of both kinds is decidedly reduced. (7) The arrangement of apparatus to measure the velocity of leakage on a small plate suspended below the car has been proved quite practicable, and far superior to the arrangement of the apparatus inside the car itself. (8) If the leakage apparatus is arranged inside a collecting cage charged with the same sign, the velocity of leakage for both kinds is materially augmented. At the third ascent, at the level of 2375 m., the velocity of leakage from positive electricity was 23 times as large as the same apparatus would have shown in a cage at ground level (as was shown by a comparison apparatus). This does not materially affect accuracy; but the advantage is secured that the number of the individual determinations is considerably increased. (9) On the third ascent large amounts of leakage were shown at high levels, evidently owing to the clearness of atmosphere, which had lasted several days, and to the descending currents. These latter had brought down from above air highly rich in ions which specially affected the apparatus, which was not under the protecting roof. (10) No disturbances were noticed, either from the charge of the balloon, or from any luminous electrical agency.

"Ueber die Kondensation an Gebirgen": von F. Pockels (13 pp.). This is a mathematical discussion of the condensation in ascending air.

"Aenderungen der Sonnentemperatur und Variationen des Regenfalls in den Ländern rings um den Indischen Ocean" (17 pp.). This is a translation of the paper by Sir J. Norman Lockyer and his son on the relation between sun-spots and rain, from the *Proceedings of the Royal Society*, vol. lxvii., 1901.

"Der Regen in Südchile": von Dr. K. Martin (7 pp.). This is a description of an extremely wet climate, with very little difference between the different months. There seems to be some ground for believing that the rain is less now than was reported by former travellers.

"Die Meteorologie um die Wende des Jahrhunderts": von Dr. W. von Bezold (7 pp.). This paper was read before the German Meteorological Society

at Stuttgart in April last. The author, well known for his researches in atmospheric physics, gives a masterly summary of the progress of the science throughout the whole nineteenth century.

"Die Berliner wissenschaftlichen Luftfahrten": von H. Hergesell (21 pp.). A work in three volumes has recently been published by Vieweg of Brunswick, giving an account of the entire work carried on with balloons and kites by the Berlin Office. Dr. Hergesell leads off with praise in unstinted measure for Mr. Glaisher as the main pioneer of balloon work. He then proceeds to discuss each several branch of the Report, and we must only refer those interested in the subject to the paper itself.

"Ueber die Richtung der elektrischen Strömung in Blitzen": von M. Toepler (6 pp.). This is an account of the examination of certain magnetisable rocks, such as Basalt, Phonolite, Dolerite, etc., in the vicinity of a spot where lightning has struck. Dr. Toepler has examined a large part of Saxony, and gives the following table:—

	Positive.	Negative.
Northern Group	5	3
Central Group	10	4
Geltsch (mountain)	7	10
Southern Group (exclusive of Geltsch) . .	37	16

"Zur Frage der Errichtung eines astrophysikalisch-meteorologischen Höhenobservatoriums im Semmering-Gebiete": von Dr. K. Kostersitz (11 pp.). As is well known, the Semmering is the highest point on the line from Vienna to Trieste, and Dr. Kostersitz wishes to erect a general observatory for physical astronomy and meteorology on the Sonnwendstein, a point distant 1½ hours on foot from the station.

"Graphische Wetterbeschreibung": von J. M. Ernst (7 pp.). This is a new idea proposed by the author at the Meteorological Congress in Paris, September 1900. He takes a series of stations situated along an almost meridional line from Vardö in Lapland to Naples, and joins the figures for the different elements at the adjacent stations by lines, so as to form continuous curves. He gives two specimens for the three days, July 11, 12, and 13, 1894, for pressure and temperature; and he shows how, by the different behaviour of the pressure and temperature in the northern stations from those in the southern stations, the great differences of weather during the days are clearly indicated.

"Das Klima im Thale des Amazonas-Stromes" and "Das Höhenklima von Uberaba, Central-Brasilien": von Prof. F. M. Draenert. At last we have some information from the interior of Brazil. Dr. Draenert in the first paper gives a very full account of the observations at Belem (Pará) on the coast, and at Manáos, 1000 miles up the river, and some notices from Señor Tabajos from eight other stations, for which, however, he does not claim absolute accuracy. The climate in the healthier parts is very good, the age of 100 years being not very uncommon; 130 years is alleged to have occurred. In the second paper the station of Uberaba lies in lat. 19° 45′ S., and long. 47° 33′ W., at an altitude of 760 metres. The paper is very fully worked out, and the observations cover three full years. It will well repay geographers to read the paper.

"Absolute Maximum-Temperaturen in Norwegen": von Prof. H. Mohn (4 pp.). This is an interesting table in which the temperatures are given, and also these figures as they would be if reduced to sea-level.

The Land of the Wine. Being an Account of the Madeira Islands at the beginning of the Twentieth Century, and from a new point of view. By A. J. DREXEL BIDDLE. Two vols. Philadelphia, 1901. 8vo.

The author's aim has been to present a faithful and reliable description of the Madeiras, and to treat their history as somewhat distinct from that of the

mother-country, Portugal, with which, it is believed, they have heretofore been too closely associated by historians. Vol. I. comprises the history of the Madeiras; information for the traveller and visitor; and a treatise on the geography, geology, and climate. Vol. II. treats of the natives, their characteristics, religion, laws, and customs; the commerce; the flora; the vine and the wine; and the fauna. Each volume has 38 full-page illustrations, as well as maps, etc.

The following notes on the climate will be of interest:—

North-east Trade-Wind.—From April 10 to September 10 the North-east trade-wind blows on Madeira, but during the winter season the island is some four degrees beyond the limits of the trade-wind, though the prevailing wind, which blows irregularly, is even then from the North-east. Occasionally in the spring the North wind blows over the central ridge of mountains and rushes down its slopes, causing damage to the vineyards.

The Leste.—The warm, dry East wind, which blows from the African desert in summer-time, and in Madeira is known as the "Leste," is the same wind which in Southern Europe strikes hot and cold in various places. In Switzerland, for instance, the African wind, there called the "Bise," is a cold, icy wind; this is because, while blowing across the peaks of the lofty Alps, which are perpetually covered with snow and ice, it loses all its heat and sand. Indeed, when it pours down into a Swiss valley it sends a chill through every one on the hottest and most sunshiny day in summer. It is when an unusually violent East wind sweeps over the great Desert of Sahara that its effects are felt in the Madeira Islands, although they are distant some 320 miles from the African coast. But strange as it may seem, the hot sand is caught up from the desert in swirling wind-clouds and thus conveyed, through the azure heights of the upper air, across the sea to the Madeira Islands; it is also thus carried to the Canaries. At Madeira such a storm appears far out at sea and coming onward with velocity.

Sand from the Desert of Sahara.—Damp cloths are sometimes hung over the windows in houses to keep out the sand with which the air is often laden at this time.

Havoc wrought by the Leste.—After the sand-storm, which occupies any time from a couple of hours to three days in passing, destruction is found in the most unlooked-for places. Holes are burned occasionally through hedges, and the leaves and smaller branches on the sides of trees exposed to the hot storm's violence are sometimes found scorched to crumbling dryness. Beyond this there is hardly if ever any other serious damage wrought that is worthy of mention; and there is very little personal discomfort felt. A distinguished resident at Madeira writes, "I never saw or felt any ill-effect from Leste."

Rain.—At the end of summer the equinoctial rains, accompanied by much lightning and little thunder, set in. The average rainfall, taken from seventeen years' observations, has been found to be 26·71 ins.

Clouds.—While the rainfall in Madeira is slight and infrequent, there is seldom a cloudless day, the mountain-peaks being constantly bathed in nebulous vapours.

The Hurricanes of the Far East. By Prof. Dr. PAUL BERGHOLZ. English Translation revised by Dr. ROBERT H. SCOTT, F.R.S. Bremen and Shanghai: Max Nössler. London: James Imray and Son. 1901. 8vo. 271 pp. and 31 plates.

Dr. Bergholz has produced a most valuable book on the subject of cyclones and hurricanes, which should be of great service to the many skilled seamen who frequent the Eastern seas. The work was published in German in 1900,

so Dr. Scott has placed English-speaking meteorologists under great obligation to him for translating it into their own language. It is also an indication of the importance and value which he attaches to Dr. Bergholz's work.

The scope of the book, which is divided into four sections, may be gathered from the following summary:—1st Section: The cyclone; origin of cyclones; movement of the atmosphere in cyclones; movement of the barometer during cyclones; rain and clouds; calm; distribution of some meteorological elements in typhoons at Manila; progressive movement of cyclones; zones of the tracks of cyclones; classification of cyclones.

2nd Section: Indications of the approach of cyclones; clouds; direction of the clouds as indications of a cyclone; photography of the clouds and their use in forecasting; indications given by the lower air currents or by the directions of the wind; indications given by the barometer; Fournier's rule, and the barocyclometer; swell and other indications of the cyclone; other indirect indications.

3rd Section: Characteristic cyclones, September 5-7, 1893; October 1-3, 1894; October 20, 1882; November 20-22, 1892; May 10-19, 1896; cyclones which pass very close to the south; the anomalies in cyclones.

4th Section: Winter storms or land storms.

Dr. Bergholz's account of the maintenance of the energy of the cyclones is as follows:—

"The reason for the energy of a cyclone and its maintenance lies in the condensation of the vapour contained in the air which is drawn into the cyclonic movement. The air at the base of the cyclone, which streams in from all sides towards the centre, is in direct contact with the surface of the land or sea; and it therefore has their temperature. In the tropics this is high, and even so if the cyclones pass through higher latitudes, and is always higher than the temperature of the upper strata of the air; it brings with it a very great quantity of vapour, which has its origin in the large evaporation from the oceans lying round. But as the air comes partly from the north, partly from the south, partly overland, and partly across the sea also, it follows that neither their temperature nor their amount of vapour can be the same. This difference in temperature and humidity, but above all, the rapid expansion of the air which is forced upwards by the eruptive vehemence of the cyclone and gets hurled outwards by the centrifugal force, have, as natural consequence, the great condensations and precipitations which are so characteristic of the cyclones in the Tropics. The condensations and precipitations take all forms, from the most delicate and highest *cirrus* to the thick and low *nimbus*, and from the drizzle to the violent torrent of rain. The equivalent of heat which is set free through the continual and extensive condensation of the vapour causes the expansion, and energetically keeps up the rarefaction of the air, as well as the depression which is necessary for the rapid aspiration of new masses of air. The latter take the place of the former; they mingle with each other, rise and rarefy themselves, and bring on their part new masses of vapour with them, by the condensation of which some heat becomes again free, creating expansion and rarefaction anew. Hence the vapour supplies, we may say, the fuel for working the terrible machine of destruction."

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THE ELEMENT OF CHANCE APPLIED TO VARIOUS METEOROLOGICAL PROBLEMS.

BY WILLIAM HENRY DINES, B.A., PRESIDENT.

An Address delivered to the Royal Meteorological Society, January 15, 1902.

BISHOP BUTLER, in his famous *Analogy*, has shown how mankind in general are compelled to regulate their conduct by considerations of probability, and how a man, who refused to act because he could not be quite certain of the result of his action, would rightly be held to be a lunatic.

Few things in the future are certain; and yet the probability of some things happening is so great that we look upon it as a certainty, and are fully justified in so doing. It is not so, however, with meteorological matters, for their uncertainty is so great that it has become proverbial, and few, save under the pressure of necessity, make any arrangements that are dependent upon the weather.

Future events may be roughly put into two classes, those about which there is no doubt, such as the rising of the sun to-morrow, and those that are uncertain, such as the occurrence of rain at a future definite time and place, but no precise boundary-line can be drawn between these classes. Strange, too, as it may seem at first sight, there is the same actual certainty about both these examples, both will be produced by the action of the so-called natural laws; and the falling of rain at a certain place and time is just as much the result of the continuous action of natural law, and the present weather conditions throughout the globe, as the rising of the sun to-morrow is the result of the regular rotation of the earth round its axis. So far as we are concerned, however, there is the fundamental difference that the one is regular, and can be foretold, whereas the other is irregular, and cannot be foretold with any certainty.

The most ignorant man who is out much at night knows when it will next be the time of full moon, but science cannot as yet say whether

to-day week will be wet or fine. We know when it will be full moon, because we have noticed that full moons occur at regular intervals, but no regular sequence of weather has ever been established, and most probably never will be. Still it does not follow that weather forecasting for more than a day or two will always be impossible, for many astronomical events can be foretold with certainty on other grounds than those of observed sequences. Before Newton's discovery of the laws of motion and gravitation, the foretelling of any astronomical event had to depend on its observed occurrence after definite intervals, and the Chaldeans could foretell an eclipse to some extent in this way, as they had observed that these phenomena had a tendency to repeat themselves after 6585⅓ days (18 years and 10 or 11 days, according to the number of leap years included). Now, however, in consequence of Newton's discovery and the advance of mathematical science, eclipses can be foretold with the greatest accuracy, and we must hope that somewhat similar methods, with similar results, may in the future be applied, to some slight extent at least, to meteorological problems.

The laws which govern the motion of the atmosphere are perfectly well known—they are, in fact, precisely those which astronomers use in their calculations—but the motion of a liquid or gas is far more difficult to investigate than that of a set of bodies such as the moon and planets. Added to this, when dealing with a gas like the air, in which changes are produced by changes of temperature and of humidity, we must take into account a fresh set of laws, namely, those known as thermo-dynamical; and in consequence the problem becomes so extremely complicated, that it is at present insoluble from the mathematical and physical side.

The result is that, for all practical purposes, weather conditions may be looked upon as purely accidental, and we may apply to them the laws of chance. They are not by any means in reality a matter of chance, for though we cannot discover it, there is doubtless a cause for each kind of weather, normal or abnormal.

Weather Forecasting.

At the present time forecasting in England has to be made on the plan of estimating various degrees of probability, and foretelling that sort of weather which on the whole seems to be the most likely. Forecasting, as is well known to most of you, is based upon the probable course of barometric depressions; and it is hardly too much to say, that if we could have barometric charts covering a large area of the temperate latitudes drawn for us for a month in advance, we could foretell the weather for that month with very fair accuracy. Taking the common case of a deep depression occurring off our Western Coasts, the forecast for the ensuing twenty-four hours depends on the course which that depression may take, and also on the question whether it will increase or decrease in intensity. In general, under the same barometric conditions, it will take a certain course, to the north-east is most usual, and the forecast is based upon this fact, and generally is correct. But the forecast is in reality only a balancing of probabilities, and is much like the case of a man drawing coloured balls out of a bag. If a bag contain nine hundred red balls and one hundred white, well mixed together, and a man draws out one ball

without looking at the colour first, he will most likely draw a red one; in the long run he will get nine red balls for one white; but yet he can never be certain that the result of his next draw may not be a white ball. So it appears to be with forecasting; a depression in most cases will take the course that a man expert in forecasting expects of it; but the case, when it does not do so, is apt to occur far more often than is desirable.

If we knew the cause and the inner working, so to speak, of the cyclones and anticyclones on which our weather depends, and knew also the precise state of the air as to temperature and humidity, not only in the surface layer, but also in the higher strata, we should doubtless be in a position to foretell the track of a depression, and eliminate very largely the element of chance that now enters more or less into all forecasts of the weather. At present this knowledge is unattainable; kites and balloons give us a certain amount of information, but what is required are regular and systematic observations at a fair number of stations. An attempt to obtain these by means of kites was made in the United States, but failed, because it was found that during a large part of the year there was not sufficient wind at many of the stations to raise the kites.

Averages.

The element of chance is, however, more intimately connected with the question of averages, and indeed with statistics in general, than with that of forecasting. Anyone who has added up many columns of daily temperatures for the purpose of finding monthly means, has probably noticed that the sum of the single column of figures standing after the decimal point amounts generally to about 135; there will be exceptions, of course, some columns being less than 100, and some few, perhaps, exceeding 200; still, if many columns be added, the mean value of the sum is certain to be close to 135. The reason of this is not far to seek. The last figure, when temperatures are measured to the tenth of a degree, is purely fortuitous, and is just as likely to be an 0 as a 9, a 1 as an 8, a 2 as a 7, and so on. Hence, when the column is sufficiently long, there will probably be as many 9's as 0's, as many 1's as 8's, as many 2's as 7's, and so on. Now 0 and 9 equal 9, 1 and 8 equal 9, etc.; a pair of figures, when added, will therefore in the long run be equivalent to 9, that is to say, a single figure may be taken as equivalent to $4\frac{1}{2}$, and in consequence the total for a month of 30 days comes out as $30 \times 4\frac{1}{2}$, that is 135. If the column is of some different length, say 50 instead of 30, it is likely to add up to $50 \times 4\frac{1}{2}$, that is 225. It is astonishing how often, in adding a set of single figures that are purely fortuitous, the total comes out close to the number given by the above rule; but it is only a particular case of the well-known law, that if you have sufficient observations accidental errors will cancel each other out.

A practical application of the above is this: to obtain the average of a long column of figures in which the last figure is a decimal and is purely accidental, neglect the last figure entirely, obtain the average without it, and then add ·45 to the average so found. If the neglected figures stand just before instead of just after the decimal place, 4·5 instead of ·45 has to be added. As a test of this I have computed the averages for each day of a month at Greenwich, for the period 1841 to 1890, and find that the

values thus obtained have not in one single instance differed from the exact average by as much as two-tenths of a degree. The question arises, may we go a step further, and neglect the two last figures, that is, confining our attention to mean temperatures expressed to the tenth of a degree; may we neglect the figure before, as well as the figure just after, the point? There are two reasons why it is not advisable to do so. One is that an error here, if there should be one, will be ten times as great, and consequently ten times more important, than if it had occurred in the figure after the decimal point. The other may produce still greater errors. In this position it is quite likely that there may be a reason for some certain figure or group of figures occurring more frequently than others. Suppose, for example, that we are dealing with the mean temperature of July, and getting the average of 50 years from the 50 separate July means. The great majority of the values would lie between 60°·0 and 66°·0, and the figure before the decimal point would not be fortuitous, but would most likely be a 2 or a 3; 7 and 8, at all events, would be unlikely figures, since a month would rarely be so cold as to give 57° or 58°, and seldom so warm as to give 67° or 68°. Nothwithstanding this, it is curious to see how nearly a temperature average value can be estimated from the first figure alone.

I wish it to be understood that I do not advocate obtaining averages in this way, where exact ones can be obtained, simply to save the trouble of adding a few figures, but bring forward the above to show that, where temperatures have been estimated only to the nearest degree, the averages obtained from them are probably correct to one-tenth of a degree.

How long is required to obtain a True Average?

A far more important question, but one closely connected with the foregoing investigation, is, how long is required to obtain a true average? It is seldom that any paper is read at our Meetings dealing with temperature, rainfall, or any other element, in which this point does not arise during the discussion. The practical answer undoubtedly is, the longer the better, but in the majority of cases only a limited time is available, and it is interesting to know the size of the error that may be introduced by using too short a time. There are two methods by which an answer to this can be given, the theoretical and the experimental, but both require a knowledge of the amount of variation that may be expected to occur.[1] Knowing the extent of this variation, a mathematical formula will give the probable error of a mean derived from a given term of years, but I prefer to treat the subject without the use of mathematics. As stated above, the ordinary amount of departure from the average is the data without which it is impossible to answer the question; and we cannot know this amount until we have some fairly long period of observations.

Temperature Averages.

Let us take a definite case as an example, and suppose that we have a correct list of the daily temperatures of May 1st at Greenwich for 50 years; the question is, how closely do we know the exact average? By

[1] *Lehrbuch der Meteorologie*, von Dr. Julius Hann, 1901, p. 107.

the term "exact average" is meant the average of a very long series of years, a thousand, say, assuming that there has been no secular change of temperature. Now 50 years will be sufficient to give us the amount of the departure from the average that may be reasonably expected to occur at this time of year, and hence to give us sufficient data. It must be borne in mind that the question is entirely one of probability. We do not know, and cannot know from the given set of figures, whether there have or have not been a preponderance of especially hot or cold days in those 50 years, but we can ascertain the extent to which such an occurrence is likely to have vitiated the average. One method is as follows:—Copy the daily temperature for each year several times, say three times, on separate pieces of paper, and shake the 150 pieces of paper so obtained well up together, separate them purely at random into three sets of 50 each, and then obtain the average value of the figures in each of the three sets. Mix up the papers again and repeat the process, until a considerable number, say 30, of average values have been obtained.

The character of these 30 averages will answer the question; if they are all close together, then the 50 years' average may be taken as being close to the true value; but if they are discordant, it is quite likely that the 50 years' average is so too. It is plain that the 30 experimental averages, if I may so call them, are obtained from 50 numbers, taken purely by chance, that fairly represent temperatures that may occur on May 1st, and hence they are numbers such as would occur if we had had a very long period of observations, and had split them up into intervals of 50 years, and taken the averages of each 50.

The discrepancies they show are therefore discrepancies such as may be expected in a 50 years' average.

Table I. has been calculated on a plan similar in principle to that just described, and the figures represent the departures from the true mean that may reasonably be expected on consecutive days of a spring

TABLE I.—Averages obtained: Figures selected by Chance.

From 10 Values.	From 30 Values.	From 50 Values.	From 100 Values.	From 10 Values.	From 30 Values.	From 50 Values.	From 100 Values.
°	°	°	°	°	°	°	°
−1·0	−1·1	−0·5	−0·8	−0·4	−0·6	+0·1	−1·4
+1·2	−0·8	−1·2	+0·8	+1·9	+1·2	+0·8	−0·4
−1·5	+0·4	+1·0	−0·7	−1·9	+1·3	+0·1	+1·0
+2·3	0·0	+0·6	+0·3	+3·6	−0·6	−0·8	+0·2
−1·5	+1·6	−0·6	−0·3	+2·9	+1·7	−1·3	−0·2
+1·2	−0·1	−0·9	−0·3	+0·6	+2·8	0·0	+0·8
−2·3	+0·2	+0·6	+1·1	+4·0	0·0	+1·4	+0·2
−1·3	−1·9	+0·1	−0·3	−0·8	+0·9	−0·9	−0·2
+1·0	−0·9	0·0	+0·2	+3·6	−1·9	0·0	+0·7
+2·0	−0·7	−0·7	−0·3	+3·0	0·0	+0·1	+0·3
−4·2	−1·1	−0·8	−0·4	−0·4	−1·1	−1·6	−0·7
+0·4	−0·8	+0·2	−0·6	−1·1	−0·3	+1·2	−0·4
−0·8	−0·5	+0·7	0·0				
−1·9	+1·3	+1·5	−0·2	Mean departures from average.	Mean departures from average.	Mean departures from average.	Mean departures from average.
+2·7	+1·1	−0·3	−0·3				
+0·8	+0·7	+0·8	+0·2				
−0·6	+0·6	+0·2	+0·3	1·7	1·0	0·7	0·5
−0·2	−0·6	+1·1	−0·4				

month in the South-east of England. If any one will take the trouble to construct a similar table, it may safely be predicted that he will obtain much the same result. The precise figures will be entirely different, but there will be about the same general amount of variation. The mean departure from the average, taken without reference to sign, will be much the same, and also the manner in which the departures occur. The one point on which there is likely to be a difference is the extreme variation.

The figures in the Table refer to a spring month in the South-east of England, but the results may easily be extended to any other season or place. Looking through the Table of Temperatures at Greenwich for April and May, it is apparent that the general range extends to about 10° on either side of the mean. In the winter the range is larger, and in consequence the accidental variations in the averages would be more for a winter month. Notwithstanding the common complaints about the changeability of the English climate, there are very many parts of the world in which the changes are far greater, nearly all of North America, for example, and in such places far greater ranges of temperature than 10° on either side of the mean are the rule. From the way in which Table I. was formed, it is evident that the accidental variations shown by the figures of that Table are directly proportional to the ordinary ranges of temperature that occur in the place to which it refers. Thus places where the daily temperature may be 20°, instead of 10°, on either side of the average, may be expected to have errors in any special number of years' average twice as great as those shown in the Table, and consequently a much longer time would be required to give as true an average value. On the other hand, places in the tropics, and more particularly tropical islands remote from a large continent, have very small variations of temperature, and in such places a comparatively short time will give a reliable average.

There are various points of interest about daily temperature curves which may receive some illumination from comparison with the figures in this Table.

Thus permanency of type, which is certainly a characteristic of weather, is shown very plainly. We see from the Table that if 50 daily temperatures, such as might occur in April or May, be taken at random, their average most probably will differ by 0°·7 from its proper value; but when we consider the actual daily means for 50 years the discrepancies are not so large.

This is shown by the two curves (Figs. 1 and 2), Curve 1 being formed from the accidental variations obtained from Table I., and Curve 2 being formed from the actual departures from the 50 years' (1841-1890) smoothed values for May at Greenwich.

The difference between the two curves is very striking; but the explanation is that the values on which the actual daily average is based are not entirely fortuitous, but are influenced by the values on the preceding days in the same year. The tendency of a set of either high or low values to follow each other in the rows tends to make the averages of the columns consecutive, and to check the variations in the daily means that would occur if the values were purely fortuitous throughout. This is shown, too, in another way.

Monthly temperatures frequently differ by as much as 3° from their mean, but from Table I. we see that the averages of 30 days, taken at random within the same limits of temperature, seldom differ by more than 1°·5 from their mean; hence there is plainly a tendency for monthly temperatures to have a bias one way or the other, that is, a month commencing with a warm period is more likely to continue warm, and one commencing cold is likely to continue cold.

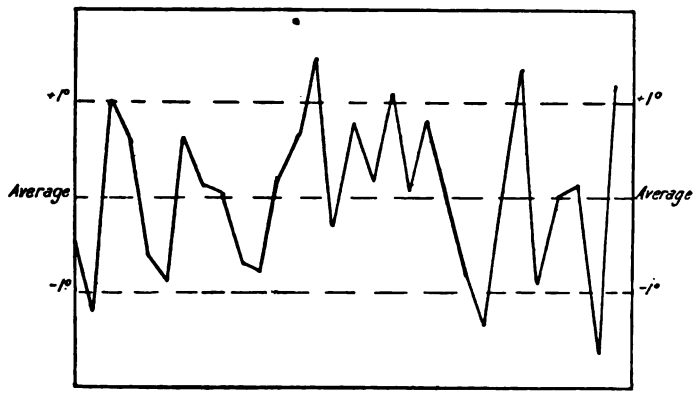

FIG. 1.—Chance curve from 50 values.

There is a question of some interest connected with the month of May. There is a widespread belief, not only in England, but also on the Continent, that the 12th, 13th, and 14th are unduly cold, and so much is this the case that these days are known in some countries as the days of the Ice Saints. It has been suggested that there is some physical cause for a lowering of the temperature at this date, such, for example, as a swarm of meteorites passing between the sun and the

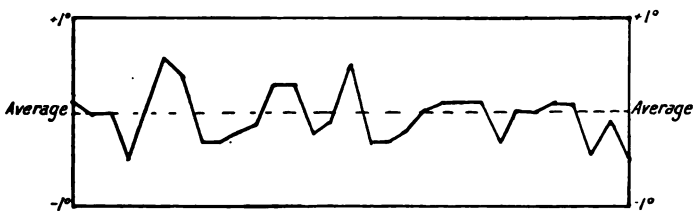

FIG. 2.—Actual departures from smoothed curve (50 years).

earth at this part of the orbit; but a far more likely explanation is that the lowering of the temperature just then is quite accidental. May, as many of us know to our cost, is a time of year when a frost may do a great deal of harm to fruit crops; and it is just the time when frosts are ceasing to be of common occurrence. A frost at this time is likely to be a noticeable event, and the common belief may have arisen in this way.

The Greenwich figures show a rise of temperature on May 16th rather than a drop on the 14th (see Fig. 2), but it is perfectly evident, from a comparison of Figs. 1 and 2, that both the rise at Greenwich on May 16th and the drop on the 14th are well within the limits that we may expect

to be reached by purely accidental causes. The fact, too, that the smoothed May temperature curve for 50 years shows no particular irregularity is a proof that the ice saints are a myth.

If we assume, as I have no doubt we may, that there are no variations of short period in the mean temperature curve, which do not arise accidentally, we can obtain the average temperature of any date by utilising the temperatures of the preceding or succeeding days. The simplest way of doing this is by drawing a smoothed curve, or preferably a harmonic curve, as Mr. Shaw has recently done.[1] It is plain, however, that we cannot get the temperature of any day quite as closely as that of the month in which it stands, but we certainly can get it more closely than we could if we had the observations made on that date alone in previous years; for we can utilise the fact that it must lie very nearly midway between the means of the preceding and succeeding days. We have seen in Table I. that the probable error of a 50 years' mean for a particular day in May is about 0°·7. It may be taken as a fairly good rule for England, and this probably holds for every climate, that a monthly temperature may depart from its mean by half the amount that a day in it may depart from its mean; and this being so, we may suppose that, did the figures of the Table refer to months instead of days, the accidental errors would in each case be one-half of those there given. Contrary to common belief, but so it appears from the Greenwich figures, the temperature variations in May are not quite as great as the average variations for the year; but on the other hand, we must not assume that we can get the daily temperature mean quite as closely as that of the month in which it stands; hence I think that for the year, taken as a whole, we may assume that the probable errors in daily temperature means are half those given in Table I.

Thus, finally, I come to the conclusion that 10-year temperature observations give a mean of which the probable error is about 0°·8, 30 years reduce this to half a degree, 50 years to one third, and 100 years to one quarter of a degree.

Before leaving this part of the subject, it may be well to point out that, while no period is too long for obtaining a good average, yet a secular change may be occurring, and hence the present average is not of necessity the mean value of the whole period. If we were fortunate enough to have very long observations, it would be necessary to divide them into two or more periods, and see that there was no secular change in progress.

It appears from the figures published by Mr. Glaisher, in a supplement to the Registrar-General's Quarterly Returns of Marriages, Births, and Deaths, that, going back 125 years, the winter mean of the first half of this period was 1°·9 lower than that of the second half. This is very considerably beyond the range of that which we might expect to occur purely by chance, and leads to a belief that a secular change is occurring in our winter climate. Doubt has been thrown upon the correctness of the early observations, but the freezing-point of a thermometer is the most easily verified point on the scale; and hence the thermometers, whatever they may have been elsewhere, were probably correct at the ordinary winter temperatures. On the other hand, the growth of London

[1] *Proceedings of the Royal Society*, vol. lxix. p. 61, 1901.

has perhaps raised the temperature, but it cannot have done so much in the open space of Greenwich Park. On the whole, it seems to me most likely that the winters are becoming milder, and this is borne out by the fact that there are repeated accounts in old records of the Thames being frozen in London, a phenomenon that has not occurred since 1814, and probably would not have occurred, even if old London Bridge had remained. Also we know that, in recent geological times, England was covered by an immense sheet of ice, and there is nothing unlikely in the supposition that the causes that produced the melting of this ice are still at work. The point, however, is one that cannot be definitely settled within the lifetime of any here to-night.

Barometer Averages.

But little need be said about the mean values of barometrical pressure. The law of their variation does not differ very greatly from that of the temperature, although greater departures occur below the mean than above it. The extreme range for the winter may be taken as about $2\frac{1}{2}$ ins., corresponding to an extreme of about 40° for the daily temperature, and an ordinary range of about $1\frac{1}{2}$ in., corresponding to about 25°. If, therefore, we may consider a temperature mean to be correct within 1°, we may consider a barometer mean for the same period as correct within ·06 in.

This only refers to the British Isles, which have a very large range. For temperate latitudes in general the probable error will not be so great.

There is one point about the barometer that may be mentioned, although our observations at the present time are not extensive enough to make it of practical importance, and that is, that the mean height of the barometer at any precise instant over the whole earth is always the same. This is due to the fact that the total mass of air is unaltered whatever be its distribution, and that the mass of water in the air, in the form of vapour or of solid particles, is so small comparatively to the air, that variations in its amount, even if they occur, are quite insignificant.

Rainfall Averages.

The time required to obtain true values for the average rainfall cannot be directly compared with that required for temperature, because the laws of variation in the two cases are entirely different. With temperatures the departures are pretty evenly distributed on both sides of the mean, and the average value of the departures is not very small when compared with the extreme values of the numbers that form it. It is very different with rainfall. In London the average daily fall is nearly 0·07 in., but the most usual quantity is none at all; and, as the late Mr. Symons tried to impress upon his observers, a fall of 5 ins. in one day is not impossible in the driest part of England. Probably few observers in the South-east of England have measured 5 ins., but most of us who have kept a record of the rainfall for any length of time have registered falls exceeding or approximating to 2 ins. If such a heavy fall chanced to come on the same day of the year twice, the rain on these two days alone would supply enough to give the average of ·07 in. for nearly 60 years, and

this being so, it is plain that a very long series of years is required to give a smooth daily rainfall curve. Happily, however, with rainfall we can use the fact that the average daily fall must be very nearly one-seventh of the average of the week in which it occurs, and, save at the times when the weekly average is changing rapidly, we may go further, and take the day's fall as one-thirtieth, or one thirty-first, as the case may be, of the monthly average. The first point is, therefore, to find the probable error of a monthly rainfall derived from a given number of years. I have adopted the method previously indicated with regard to temperature, but have been content to ignore the difference between the spring and autumn months, and to take the months as though all had the same rainfall. Also, since the rainfall of a district is of more importance in the matter of water-supply than that of one single station, I have used the figures for a district, namely, the London district. The monthly falls tabulated by my father (the late Mr. G. Dines) for the London district were copied on separate pieces of paper, shaken up and taken at random in sets of 10, 30, and 60, and the averages tabulated.

The results are given in Table II.

TABLE II.—Monthly Rainfall Averages taken by Chance.

10 Months.		30 Months.		60 Months.	
Average.	Departure from mean.	Average.	Departure from mean.	Average.	Departure from mean.
ins.	in.	ins.	in.	ins.	in.
1·84	−·24	2·16	+·09	2·05	−·02
1·91	−·17	2·13	+·06	2·04	−·03
1·81	−·27	1·76	−·31	2·14	+·07
2·20	+·12	2·18	+·11	2·17	+·10
2·34	+·26	2·08	+·01	2·04	−·03
2·24	+·16	2·09	−·07	2·27	+·20
2·03	−·05	2·42	+·35	1·86	−·21
1·39	−·69	1·90	−·17	2·10	+·03
2·29	+·21	2·20	+·13	2·15	+·08
2·67	+·59	1·77	−·30	2·10	+·03
2·50	+·42	1·89	−·18	1·84	−·23
2·01	−·07	2·07	...	2·20	+·13
1·74	−·34	2·18	+·11	2·27	+·20
1·54	−·54	2·33	+·24	2·34	+·27
2·16	+·08	2·40	+·33	1·96	−·11
1·95	−·13	2·00	−·07	2·03	−·04
2·50	+·42	1·74	−·33	2·08	+·01
2·39	+·31	1·95	−·12	2·07	...
1·74	−·34	2·02	−·05	2·06	−·01
2·55	+·47	2·17	+·10	1·82	−·25
2·53	+·45	1·81	−·26	1·97	−·10
1·63	−·45	2·01	−·06	2·15	+·08
1·85	−·23	2·03	−·04	1·79	−·28
1·57	−·51	2·00	−·07	2·04	−·03
2·06	−·02	2·28	+·21	2·26	+·19
2·33	+·25	2·26	+·19	2·06	+·01
2·25	+·17	2·26	+·19	2·22	+·15
2·20	+·12	2·20	+·13	2·20	+·13
2·39	+·31	1·99	−·08	1·90	−·17
1·84	−·24	1·90	−·17	2·06	−·01
Mean 2·08	·29	2·07	·15	2·07	·10

It appears from this that, if we have only 10 years' record, it is quite likely (4 times out of 30 in the table) that the error in a month's average may exceed ·50 in., and most probably it amounts to ·29 in.

For 30 years the figures are—

An error of ·30 in. likely (5 out of 30).

An error of ·15 in. most probable.

For 60 years an error of ·20 in. likely (7 out of 30).

An error of ·10 in. most probable.

These quantities refer to a monthly fall of a little over 2 ins., and may be taken as holding for places in England where the annual fall is not over 30 ins. If expressed as percentages, I think they hold for the whole of the British Isles.

In countries where the distribution of rain throughout the year is different, and the variations for any month larger or smaller than in England, they will not apply.

A week, roughly, is one quarter of a month, and a monthly average of 10 years depends on a rather greater number of individual entries than a weekly average of 40 years. It is, therefore, apparent from Table II. that no weekly averages that are yet in existence can be relied upon for accuracy, and also, since few districts have a 60 years' record, we do not yet know the value of any monthly rainfall average within 10 per cent. Another conclusion, is that we must not feel too certain about the times of maximum and minimum rain, since it is possible that these dates may be greatly modified by another 50 years' observations.

Annual averages may be investigated in the same way, but it seems unnecessary to enter into this question, as it has been fully treated of by Sir A. R. Binnie.[1] It is plain that annual variations, which may be 33 per cent below or 50 per cent above the mean, are greater than the chance variations of 12 months taken at random would lead us to expect, thus showing that wet months, like warm days, have a tendency to follow each other, and similarly for dry months. This tendency, as we shall subsequently see, appears also to hold for wet and dry years.

Weather Fallacies.

Mr. Inwards, in a Presidential Address to this Society in 1895 dealt with the question of weather fallacies, and pointed out how the chance coincidence of two entirely independent events would start a fallacy. There are still in existence an immense number of popular fallacies, and, as Mr. Inwards truly said, they are maintained by the fact that favourable examples are remembered, but cases of failure are entirely ignored. Fresh fallacies are constantly being started, having for their object the sun, the moon, the planets, and, perhaps one may say, every conceivable object in the heaven above or the earth beneath; the moon, however, still being, as perhaps it always has been, the favourite. While the old fallacies, such as those relating to St. Swithin, to the behaviour of birds, etc., still hold their ground, the freshly-started ones do not receive, I fancy, much credence from any one save their authors. There are still educated people who believe in weather almanacs, even to the extent

[1] *Minutes of Proceedings of the Institution of Civil Engineers*, vol. cix., 1891-92, part iii.

of taking or not taking an umbrella, though it is difficult to see how any belief could long survive so practical a test.

A little consideration will show that the coincidences on which these fallacies are started and maintained are inevitable. Take the case of a weather almanac, and see if it is possible that one should be written which shall not contain a considerable number of accurate predictions. In this part of England a measurable quantity of rain falls on the average on about half the days of the year, so that it is an even chance if any particular day be counted as fine or rainy. The almanac-maker, therefore, in dealing with the question of rain alone, has just as good a chance of being correct as of being incorrect, and it would be just as difficult for him to produce an almanac in which there was not one successful prediction of rain, as to produce one in which every prophecy of wet proved true. Indeed, an almanac that was never right would be an extraordinary production, and would imply some kind of superhuman knowledge of the weather on the part of its producer.

Very similar considerations will hold with regard to the various theories relating to the moon. A thing that is inherently likely is believed on trifling evidence, but a thing that is inherently improbable requires very strong evidence to support it. *A priori* it is very improbable that the moon should influence our weather; it gives us no appreciable heat; it is doubtful if the aerial tide which it must cause is large enough to be detected; no electrical effect is apparent; how then can the moon influence the weather? The evidence put forward to persuade us that it does is of the flimsiest description, and fails at once when considered in the light of the theory of probability. It generally comes to something of this kind, that during one stage in the moon's course the rain has been so much in excess of the average, and during another stage there has been a deficiency of so much, but these excesses or deficiencies are just such as those we may expect to occur accidentally. There are many elements in the weather that can be placed side by side with the phases of the moon; and beside the phases there is the position of the node and the position of the apse, both of which may be brought into account; and it would be odd if now and then there were not apparent coincidences between the many pairs of combinations that can be formed. All completely fail to meet the test of lasting for a time sufficient to show that they are not purely accidental.

Weather Cycles.

Weather cycles are another set of meteorological problems to which the theory of probability may be usefully applied. The seasons, with their accompanying phenomena, such as the rainy season of the tropics, are weather cycles in the strict sense of the term, and also daily changes of temperature, but it is only to cycles of which the period is not a day or a year that the term is usually applied. It seems to me that if there were any true cycles of a period of not more than 10 or 15 years, they must have been discovered before now, for we have about 100 years' precise observations, and any regular periodical occurrence continuing throughout that time could hardly have been overlooked. There is not much room for pure chance to give rise to imaginary cycles, since not

only alternations of weather continued for some time are necessary, but also alternations occurring at regular intervals. The easiest and simplest way of looking for a weather cycle is to put the special element considered into the form of a curve; the cycle then, if there be one, appears as a series of regular waves, the same distances, or approximately so, appearing between all the crests, and equally so between all the troughs. This is plainly apparent from Fig. 3, in which it is impossible to miss

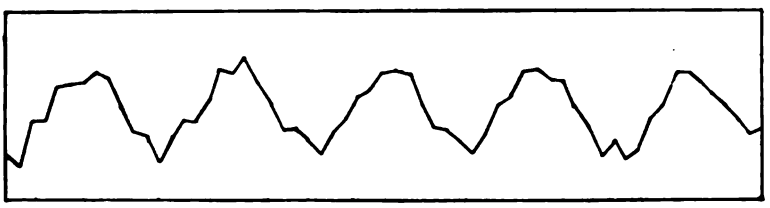

FIG. 3.—Curve showing the Mean Temperature for 60 consecutive months.

seeing the regular sequence of the seasons. What chance there is of such a thing occurring purely by accident is easily found out by a direct trial. We require a set of figures for ordinates, the value of which are entirely chance ones, and a convenient way of obtaining these is to use the digits standing after the decimal point in a table of daily temperatures. These digits cannot be used as they stand for ordinates, because every 9 that occurred would give a crest of the curve at exactly the same height, and every 0 a trough of the same depth, but they can easily be combined in sets of three or four consecutive figures. A better plan perhaps is to use the figures as they stand, and smooth the curve so formed by the formula $\frac{a+2b+c}{4}$. M and N (Fig. 4) have been so obtained from the figures after the decimal in the daily temperature at Greenwich, commencing from January 1st, 1841.

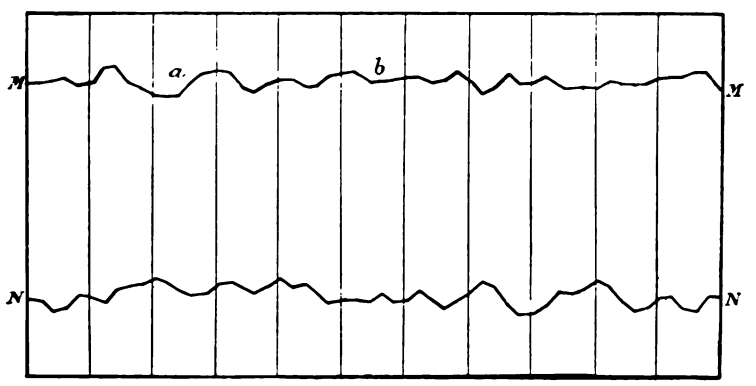

FIG. 4.

These curves show the extent to which chance variations of the weather may present the appearance of a cycle. There are three fairly regular waves a little before the middle of curve M, and if this curve were one representing annual temperatures or rainfall, and the piece between

(*a*) and (*b*) stood alone, it might not unreasonably be used to support the theory of a 5-year period. The other parts of the curve do not fit in at all with this idea, and a similar want of correspondence generally overtakes the supposed weather cycle when the period dealt with is sufficiently long. The parts are placed the one below the other, to show the amount of agreement that may be traced or imagined between two things that are known to be entirely independent.

There is one set of weather cycles to which special reference should be made, namely, the set of which the period is 10 years. The sunspot cycle is of 11 years, and this is often supposed, though I believe incorrectly, to influence the weather, but there is no cause known that should produce a 10-years' cycle. The fact that the human race possess ten fingers has been the starting-point of many supposed cycles. Our ten fingers have led to the almost universal system of counting by tens, and thus after ten years we come to another year which is expressed by a number ending with the same figure. If by chance a year ending with a certain figure has in it some special weather characteristic, and this appears again after ten and twenty years, the coincidence is more noticeable that if it had occurred with some other interval between. The statement that years ending with a certain figure are specially marked in some way, by a hot summer or a wet autumn, for example, is constantly occurring; and no doubt many curious coincidences of the kind can be found that hold for 50 years or perhaps longer. This is, of course, equivalent to setting up a cycle of 10-years' period, because if an event occurs at intervals of 10 years, it must occur in years that end with the same figure. It is difficult, however, to suppose that there is anything in these coincidences not entirely due to chance.

Another phenonemon that may or may not be due to some precise physical cause is the repetition year after year of some special kind of weather. If the special weather be of what may be called a popular kind, a kind, that is, that is generally acceptable, it passes without remark, but not so if it be of an unpleasant character. Probably comparatively few Londoners know that a very unusual run of hot dry summers has occurred since 1893, although those responsible for a supply of water, and farmers whose chief business is grazing, are well aware of the fact. Preceding 1893 there were five consecutive cool summers, some of which were wet, and in this case there was much talk about the matter. Indeed, the dwellers in a large town in general, and the journalist in particular, seem to look upon rain as an unmitigated evil, and to consider that a wet month is a calamity comparable to a famine or the loss of a battle, quite forgetting that, could there be a year without rain throughout the world, but few men or animals would survive the want of food that would ensue.

To return, however, to the question whether these phenomena are purely due to chance or not. If we calculate our averages to a sufficient number of decimal places, we may take it for granted that no given year or month will agree exactly with the average, and hence we may consider all values as being either above or below the mean. What then is the chance that some given number, say 10, *plus* or *minus* signs shall occur consecutively, or that in 10 consecutive years there shall be 8 or 9 signs of the same kind? This question is easily answered, and we find that,

in a period of 50 years, it is rather more likely than not that somewhere there will be a set of 6 consecutive-like signs.

As in the other points to which I have alluded, it is not necessary to appeal to mathematics to discover this; the columns of figures standing after the decimal point in any set of air temperatures may be used to supply the answer. It is an even chance whether such a figure be greater than 4 or less than 5, just as it is an even chance whether a special month or season be hotter or colder than the average. Take, therefore, a set of daily temperatures, and if the last figure be greater than 4 put a + against it, and if less than 5 put a −, and arrange the *plus* and *minus* signs consecutively as they occur. An equally simple plan is to toss a coin, counting a head as a + and a tail as a −.

It will be found that sums of 4 or 5 consecutive like signs are fairly common; a set of 6 will occur about once in every 40, but a set of any number exceeding 8 or 9 is not likely to occur. Hence we may conclude that 6 consecutive seasons of the same kind may be expected to occur purely by chance, but that if, in 50 or 100 years' observations, we can find instances of similarly marked seasons being repeated consecutively for 9 or 10 years, we have reason to think that this is due to some special cause. I should be inclined to think that the persistent want of rain of recent years, following as it has a run of wet years, had been due to some such cause, were it not almost impossible to imagine any effective and sufficient agent capable of producing it.

Conclusion.

Having thus briefly reviewed some of the meteorological problems in which we are bound to take in the consideration of chance in order to arrive at a correct solution, one is naturally led to wonder how far in the future meteorology may be raised above such a necessity. In so far as it is a statistical science, the rules of statistics must always be applied to it, and these rules are only deductions from the mathematical theory of probability.

The neglect of these rules, which the eminent mathematician Laplace described as "common sense reduced to calculation," has led to curious results in other subjects as well as in meteorology, and has been the cause of the saying that "figures will prove anything." Figures certainly will not prove anything, but to those who accept *post hoc* and *propter hoc* as equivalent terms, statistics cleverly manipulated may be made to present a plausible case for almost anything.

But meteorology is far more than a statistical science, and is very closely dependent upon theoretical mechanics and thermo-dynamics; and in the application of these subjects to meteorology lies the best hope of advance. Unfortunately this application often requires the possession of very exceptional mathematical skill, and but few of those who possess the skill have been willing to turn their attention to the subject. But with the comparatively limited knowledge of mathematics to which I can lay claim it is possible to answer many meteorological questions; and also, I am afraid it must be added, impossible not to see that many current explanations of meteorological phenomena are in fundamental opposition to well-established mechanical and dynamical laws.

It is in the hope that my remarks may help in the extinction of some

of those fallacies that were scotched, but, alas, not killed, by Mr. Inwards six years ago, and may encourage the use of rational and scientific methods, that I have ventured to bring this somewhat uninteresting subject before you to-night.

Atmospheric Dust.—In the *Monthly Pilot Chart* of the North Atlantic and Mediterranean, issued by the Meteorological Office, for the month of January 1902 there appeared the following remark among others under the heading Fog:—"On the African Coast, from Cape Verde southward, the land is often obscured by a low-lying treacherous haze, which calls for caution in navigation. There is also a great deal of misty haze, if not fog, about the Cape Verde islands; and haze in some seasons very dense, due to 'Red Dust,' extends far out on the eastern side of the Atlantic southward from the 35th parallel. In February 1898 the R.M.S. *Briton* entered a cloud of red dust 80 miles south of Madeira, and for a distance of over 2000 miles was dependent for her position on dead reckoning. She emerged from the haze when between 400 and 500 miles south of Cape Verde. In consequence of the density and persistency of this haze vessels were delayed as much as two or three days, one steamer occupying two and a half days in running the short distance between Teneriffe and Las Palmas, the run usually being accomplished in about 5 hours."

Since the publication of the foregoing a gale is reported to have visited the Canary Islands on January 17 or 18, and a dust storm to have been experienced in some districts.

On Friday, January 17 in the early morning the mail steamer *Lagos* outward bound, went ashore on one of the Dezertas islands, near Madeira, during what is described as a dense fog. She became a total wreck.

The mail steamer *Raglan Castle*, which arrived at Las Palmas from London early in the morning of January 18, reported that from 33° N. to 29° N. she had met with a strong South-south-east wind, and that the atmosphere was thick with fine sand causing a fog-like appearance. The Lisbon correspondent of a London newspaper, writing on January 25 mentions, in connection with the wreck of the steamer *Lagos*, "an unexplained phenomenon observed in different localities in Portugal. The leaves of the trees and the vegetables were thickly covered with a brownish yellow dust resembling cinnamon."

The deposit of this atmospheric dust so far north as Lisbon is unusual. Later reports show that it has recently occurred in higher latitudes.

The Secretary of the Meteorological Office has received a communication from the Secretary to Lloyds, Colonel H. Hozier, enclosing an extract from a letter (dated January 23) received by him from the Signalman in charge of Lloyds Signal Station at Barry Island, together with a specimen of the salmon-coloured dust to which it refers. This dust closely resembles that which fell at Fiume in the night of March 10-11, 1901, but appears to be of a somewhat coarser grain.

The extract from the report of the Signalman is as follows:—"I also beg to inform you that a very queer thing happened here last evening; there was a light wind from West with a wet fog. This morning I noticed the iron railings were coated with a salmon-coloured dust, although rather wet, I did not take much notice of it. Later in the day I found that the base of the railings was completely coated, and I have scraped a small portion off and am sending it to you. Probably you will send it to the Meteorological Office. We have not had any length of dry weather for some time, rain falling nearly every evening for the last three weeks, so it could not be dust. I called the attention of Mr. Waite (the Water Engineer at Barry) to it. He tells me it is something remarkable. I cannot account for it. Some call it *pink rain*. I found myself that my overcoat and cap, after being out last evening, had a red appearance this morning."—Captain M. W. CAMPBELL HEPWORTH.

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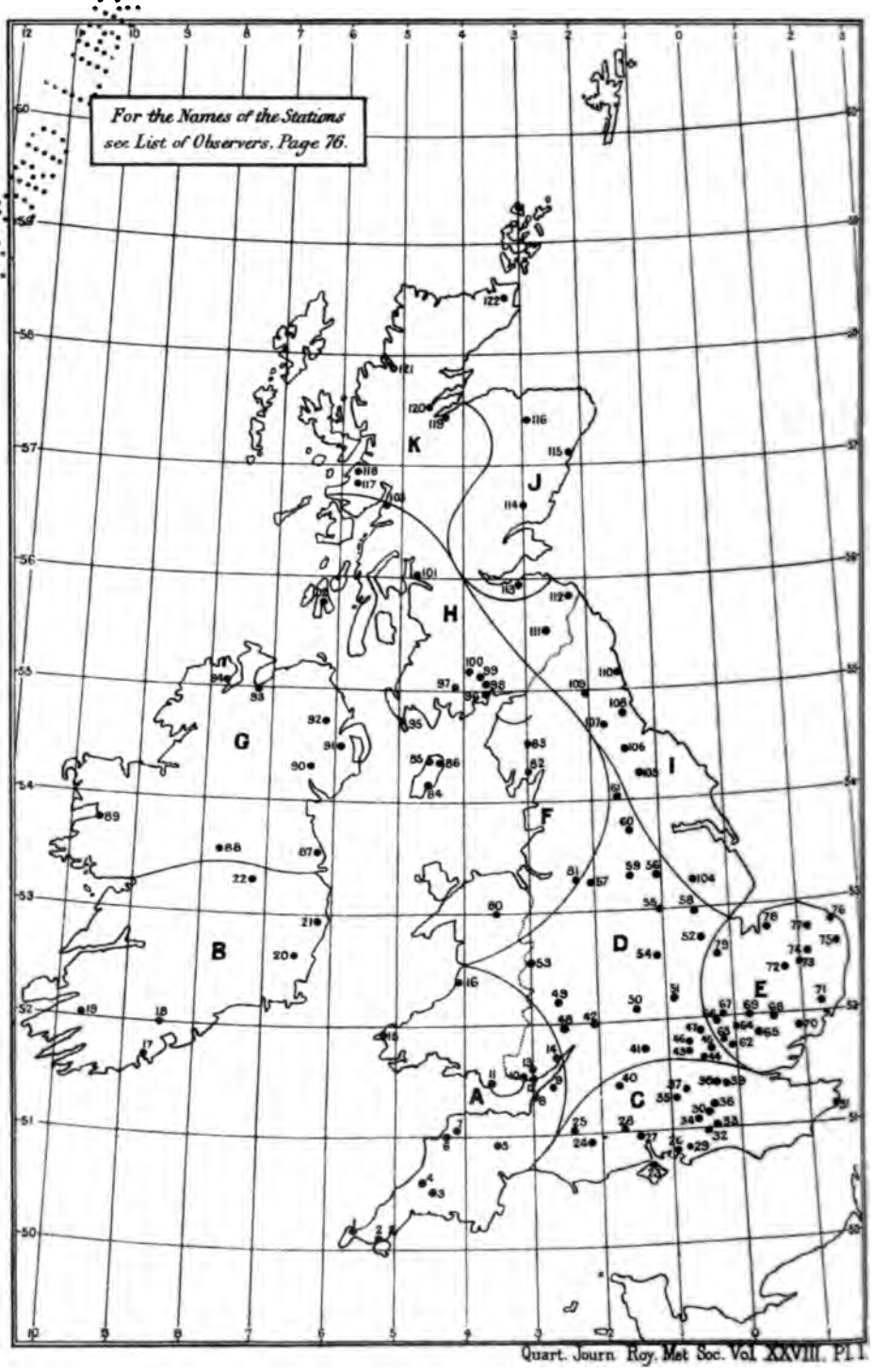
MAP SHOWING POSITION OF THE PHENOLOGICAL STATIONS, 1901.



REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1901.

By EDWARD MAWLEY, F.R.Met.Soc., F.R.H.S.

(Plate I.)

[Read February 19, 1902.]

The following changes have taken place in the observing stations since the last Report was issued. No returns were received during the year from Tresco and Gowerton in District **A**; Cappagh and Glendalough in District **B**; Breamore in District **C**; Wealdstone and Ullenhall in District **D**; and Glan Conway in District **F**. On the other hand, new stations have been started, or old ones revived, at Ovoca in District **B**; Fordingbridge and Birdham in District **C**; Watford (Oxhey Lane) in District **D**; Wenden and Carleton-Forehoe in District **E**; Newby Bridge in District **F**; Kirkmaiden, Carsethorn, Dumfries, and Moniaive in District **H**; Durham in District **I**; and Edinburgh in District **J**. The total number of observers is now 125.

The averages with which the mean dates of the different plants are compared in Table IV. have been obtained from the actual observations made during the 10 years 1891-1900 in all those districts where sufficient observations were available. Those for the remaining districts are as near approximations to the true averages as the limited number of records available will allow.

TABLE I.—Mean Results, with their Variations from the 10 Years' Average (1891-1900), for the Thirteen Plants in those Districts where there have been sufficient Observations to warrant Comparisons being made.

Years.	Eng. S.W.		Eng. S.		Eng. Mid.		Eng. E.		Eng. N.W.	
	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.	Day of Year.	Variation from Average.
		Days.		Days.		Days.		Days.		Days.
1891	144	+11	144	+10	150	+11	147	+11	150	+ 8
1892	139	+ 6	138	+ 4	144	+ 5	143	+ 7	147	+ 5
1893	118	-15	122	-12	125	-14	123	-13	128	-14
1894	126	- 7	130	- 4	135	- 4	127	- 9	137	- 5
1895	139	+ 6	138	+ 4	141	+ 2	138	+ 2	144	+ 2
1896	125	- 8	128	- 6	132	- 7	130	- 6	134	- 8
1897	130	- 3	132	- 2	136	- 3	132	- 4	142	0
1898	133	0	135	+ 1	138	- 1	136	0	141	- 1
1899	136	+ 3	136	+ 2	141	+ 2	138	+ 2	145	+ 3
1900	142	+ 9	141	+ 7	144	+ 5	143	+ 7	152	+10
1901	138	+ 5	139	+ 5	141	+ 2	139	+ 3	144	+ 2
Mean	133	...	134	...	139	...	136	...	142	...

Explanation of the Dates in the Tables.

1- 31	are in January.	182-212	are in July.
32- 59	,, February.	213-243	,, August.
60- 90	,, March.	244-273	,, September.
91-120	,, April.	274-304	,, October.
121-151	,, May.	305-334	,, November.
152-181	,, June.	335-365	,, December.

The Winter of 1900-1.

This was, on the whole, a mild winter. December proved remarkably warm, the departures from the average in mean temperature ranging from + 4°·3 in the south of Ireland and north of Scotland, to + 7°·0 in the north-east of England. January was of about a seasonable temperature, but during February the weather continued very cold throughout a great part of the month all over the country. The rainfall of the quarter was in most districts in excess of the mean, while the records of sunshine were everywhere poor.

The exceptional mildness of December, together with the warmth of the preceding autumn, caused the pastures to remain unusually green until the growth of the grass was checked by the frosts and cold winds in February. Turnips and swedes, considering the time of year, also continued to make surprising growth in the early part of the winter. The recently sown corn likewise made good progress during the same mild period, while the heavy rains were rather beneficial than otherwise by causing the soil to become firm round the young plants. Then again, owing to the dry and open character of the weather in the autumn, all seasonable tillage operations were unusually forward. So that it was only in February, when the sowing of spring corn became due, that the unworkable condition of the land, at first through the constant wet, and afterwards through snow and frost, began to be seriously felt.

An unusual number of garden plants remained in flower during a great portion of December. Roses, for instance, are mentioned by observers in different parts of the country as here and there still in bloom until nearly Christmas, an exceptional circumstance anywhere except in the warmest parts of our islands. The unusual mildness of the first two months of the season also favoured the growth of all winter vegetables. The saturated condition of the ground in the early part of the quarter caused many interruptions in the transplanting of trees, shrubs, etc., and also in the cultivation of the soil; but, on the other hand, there at no time occurred sufficient frost to do injury to any but the most tender of garden plants.

Taking the country as a whole, the flowering of the hazel took place 1 day after its usual date.

The notes of the song-thrush were first heard after the beginning of the year, 8 days earlier than usual.

The honey-bee was first observed to visit flowers 4 days after its mean date.

The Spring.

March proved very cold, but during April and May the temperature continued, as a rule, rather high. The fall of rain was somewhat variable, but, taking the season as a whole, was in most districts slightly below the average. In all parts of the British Isles this was an unusually sunny spring.

Seldom has there been a spring in which the sowing of spring corn and other seeds was as greatly delayed. Indeed, until after the middle of April the land, owing to the frequent heavy falls of rain, continued too wet and cold for any satisfactory progress to be made. After that

time the weather remained so propitious, and the ground dried so quickly, that all arrears of sowing were rapidly made up. Nevertheless a great deal of spring wheat, barley, and oats was sown under very unfavourable conditions, and much more very much later than is desirable. So complete was the change from wet to dry weather in the middle of the season that before the end of May farmers were everywhere crying out for rain. This was urgently required for the grass, which, owing to the scanty rainfall of the previous six weeks, and the cold North-easterly winds, had made but little growth, and more particularly but little bottom growth. Rain was also needed for the sowing and germination of the seed of mangolds and other roots.

This was almost as unfavourable a season in the garden as in the field, first through the cold and wet condition of the soil and afterwards owing to the continued dry weather, which at sowing time is always more keenly felt by the gardener than the farmer. The show of fruit blossom in different districts, and even in different parts of the same district, was very irregular. That on the pears, plums, and cherries was fairly abundant, but there was, as a rule, very little blossom on the apple trees. The North-easterly winds were somewhat trying, but as some compensation there was in most places an unusual freedom from late spring frosts.

The flowering of the hawthorn appears to have been in many places very sparse.

All the spring plants on the list were backward in coming into flower, the coltsfoot being 1 day late, the wood anemone 6 days late, the blackthorn 11 days late, the garlic-hedge-mustard 6 days late, the horse-chestnut 3 days late, and the hawthorn 6 days late.

Most of the spring migrants were slightly behind their mean dates in reaching these shores. The swallow was 1 day late, the cuckoo 2 days late, the nightingale 2 days early, and the fly-catcher 2 days late.

The wasp made its appearance 12 days late, the small white butterfly 5 days late, and the orange-tip butterfly 3 days late.

The Summer.

Regarded generally, this was only a moderately warm summer; but in July the weather proved exceptionally warm—the departure from the average in mean temperature varying from $+2^{\circ}\cdot4$ in the east of England and the north of Ireland to $+4^{\circ}\cdot2$ in the midlands and in the eastern counties of Scotland. In all parts of the kingdom there was a deficient rainfall, and in most districts a singularly good record of sunshine.

The dry weather during the latter half of the spring extended into this quarter, and may be said to have continued throughout the greater part of it. The hay crop was almost everywhere a very light one; for although in Scotland and Ireland the yield was much better than in England, the rain even there came too late to be of any material service to the crop, although in the districts thus favoured it greatly improved the appearance of the pastures. In all the drier parts of the country, of the three leading cereals, wheat withstood the drought best, next came barley, and lastly, that moisture-loving cereal, the oat, which suffered considerably. The autumn-sown corn had a great advantage in such a

dry season over that sown as late in the spring as it was in 1901, but in all cases the straw was much shorter than usual—indeed this was one of the most noteworthy features of the season.

Almost as late as mid-summer day the harvest promised to be unusually backward, but the dry weather and exceptional heat in July caused the corn crops to become rapidly matured.

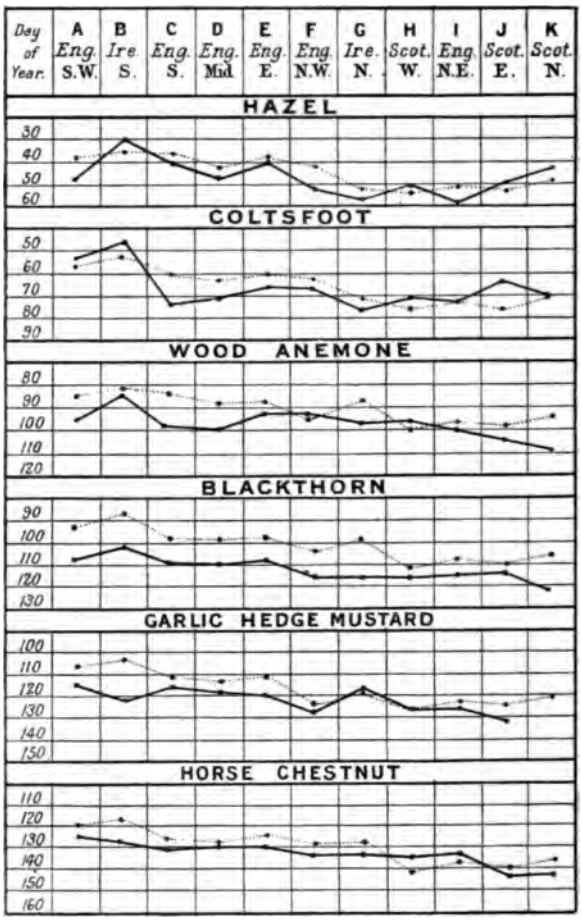


FIG. 1.

This was a very unsatisfactory summer for the root crops in England, owing to the continued dry weather. In many cases they had to be re-sown, and when the seed had germinated the plants made but slow and irregular growth. Mangolds as usual withstood these adverse conditions much better than either the swedes or turnips. The pastures in all but the northern districts of England, and in Scotland and Ireland, remained parched and bare throughout the season.

The summer drought and great heat in July checked the growth of

vegetables considerably, indeed the dry state of the air and soil caused the growth of most garden plants in the southern half of England to remain during a great part of the season nearly stationary, so that their flowering period was much shortened. The lawns, as usual, under such conditions gradually became very brown.

Owing doubtless to the dryness of the season an unusual amount of

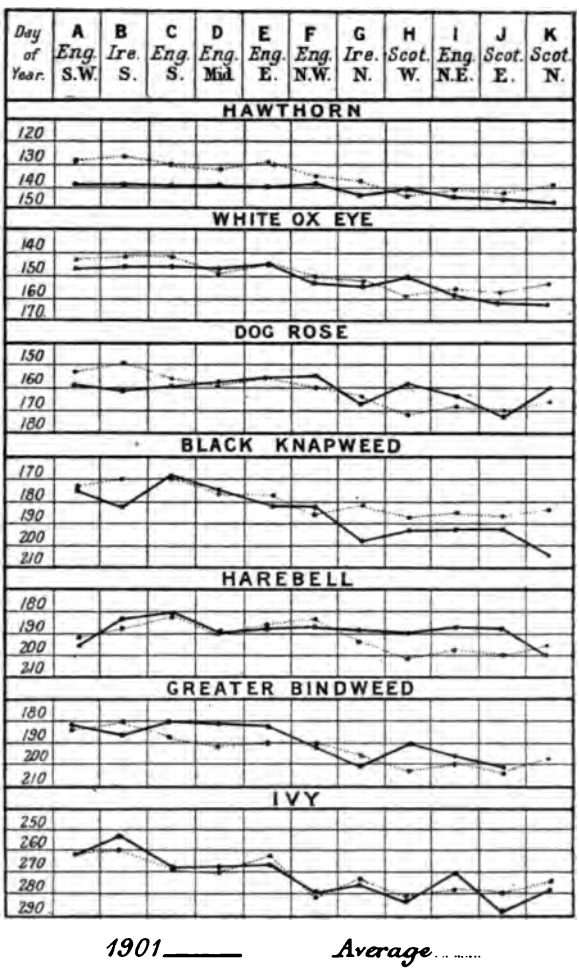


FIG. 2.

damage is reported to have been done to fruit of all kinds by birds; not only were the small fruits attacked, but also apples and pears.

The small and large white butterflies were unusually numerous.

The white ox-eye flowered 2 days late, the dog-rose at its average date, the black knapweed was 6 days late, while, on the other hand, the harebell was 4 days early and the greater bindweed 3 days early.

The meadow-brown butterfly first made its appearance 7 days early.

The Autumn.

In September and October the temperature ruled high, but, on the other hand, in November the weather was almost everywhere unusually cold. The most noteworthy feature of this autumn was, however, the scanty rainfall in the southern half of England—the deficiency amounting to – 5·6 ins. in the south-west, to – 3·8 ins. in the south, to – 3·6 ins. in the midlands, and to – 2·6 ins. in the eastern counties. The records of sunshine varied greatly, but in most districts were in excess of the mean.

The harvest in the colder parts of these Islands was completed, as has been before pointed out, at an unusually early date.

The cooler weather in September, followed by the moderate but rather frequent rains in October, allowed the pastures which had hitherto remained bare to gradually recover their verdure; and from that time until the end of the season, notwithstanding the small rainfall in November, there was never any lack of grass for the cattle and sheep. The roots, too, in the same way made for the first time in the drier districts satisfactory progress. The crops of swedes and turnips were, however, very irregular, being good where favoured by rain in the summer at critical periods of their growth, and very scanty where these timely showers had been missed.

The long drought of 1901 may be said to have lasted throughout the greater part of England from the middle of April until the end of September, or for 5½ months. That is to say, during the whole of that time there was never enough rain to moisten the soil sufficiently for it to be of any lasting benefit to the growing crops. It was only towards the end of September that the preparation of the land for autumn-sown corn could be proceeded with, owing to the hardness of the ground. But when once sufficient rain had fallen rapid progress was made, and before the end of October a good deal of wheat had been already sown. As is often the case after a long period of dry weather, the land worked so well that the seed bed provided was an exceptionally good one.

The weather of this season, which had proved so favourable on the farms, was equally satisfactory in the garden. The stunted vegetables to a great extent recovered, and had made fair growth before the winter season set in. In the flower garden this was an unusually gay season.

The autumnal tints were singularly fine, and trees retained their foliage, as a rule, longer than usual. The yield of wild fruits varied greatly, but blackberries, acorns, and horse-chestnuts were in most localities remarkably abundant. During September there was in many places an unusually good crop of mushrooms.

Wasps are reported as having been numerous in most parts of the country.

The ivy flowered at its average date.

Swallows as a rule left this country about 2 days earlier than their usual time.

According to the preliminary statement for Great Britain issued by the Board of Agriculture, the yield of wheat exceeded the average for the previous 10 years by 0·91 bushels per acre; whereas barley fell short of the average by 2·15 bushels per acre, and, with the single exception of 1893, was the lowest since official returns were first issued in 1884. Oats fell short of the average by 1·73 bushels per acre, which is, with two

exceptions, 1887 and 1893, also the lowest in those records. On more closely examining these estimates, it will be found that while wheat was less than a bushel per acre in excess of the average in England, it was more than 2 bushels in excess in Scotland; that barley was $2\frac{3}{4}$ bushels an acre below the average in England, but half a bushel above it in Scotland. A similar difference manifests itself with the oat crop, which was $3\frac{1}{4}$ bushels an acre below average in England, whereas in Scotland it was $1\frac{1}{4}$ bushels above average. Taking the three cereals together, the average yield in England was nearly 9 bushels an acre below that in Scotland. Regarding the British Isles as a whole, the corn harvest began 6 days in advance of the mean date for the previous 12 years. In all parts of the kingdom the crop of hay was a small one, the deficiency being greatest in the southern half of England. Turnips and swedes were under average in England, but above average in Scotland and Ireland, while mangolds were nearly everywhere more or less above average. Potatoes were only about average in England, but proved unusually abundant crops in Scotland and Ireland. Beans and peas were under average in England, but in excess of the average in Scotland and Ireland. Hops produced the high average yield of 12·7 cwt. per acre, which is very slightly below the record crop in 1899.

The yield of fruit was unusually poor. The crop of apples was more or less deficient in all parts of the British Isles, and especially so in the south of England. Pears and plums were also under average, but not nearly to the same extent as apples. There were excellent crops of raspberries, currants, gooseberries, and strawberries.

The Year.

As affecting vegetation the weather was chiefly remarkable for the scanty rainfall during the growing period of the year. The deficiency was not confined to any part of the British Isles, but was more keenly felt in the English counties than in either Scotland or Ireland. Wild plants came into flower very late, but not quite as late as in the previous year, which was an exceptionally backward one. The swallow, cuckoo and other spring migrants were, as a rule, rather behind their usual dates in reaching these islands. The crops of wheat, barley, and oats were all more or less above average in Scotland and Ireland. On the other hand, in England, although there was a fair yield of wheat, that of barley and oats was very deficient. Hay proved everywhere a small crop, and especially so in the southern districts of England. Beans, peas, turnips, swedes, and potatoes were mostly under average in England, but either good or fairly good elsewhere. The yield of hops proved singularly abundant. Apples, pears, and plums were nearly everywhere below average, especially apples, but the small fruits, as a rule, yielded well. Taking farm and garden crops together, seldom has there been in England a less bountiful year.

Observer's Notes.

December 1900.—*Mawnan* (A)—Holly-berries were later in ripening than usual, so were plentiful at Christmas. *Altarnon* (A)—24th. Ripe blackberries gathered. 26th. Blackbird building. 28th. Trees blown down by westerly

TABLE II.—List of the Stations with the Names of the Observers.

Station.	County.	Height above Sea-level.	Observer.
A		Ft.	
1. Marazion	Cornwall	40	F. W. Millett.
2. Mawnan	Cornwall	200	Miss R. Barclay.
3. Liskeard	Cornwall	400	S. W. Jenkin, C.E.
4. Altarnon	Cornwall	600	C. U. Tripp, M.A., F.R.Met.Soc.
5. Tiverton	Devon	270	Miss M. E. Gill.
6. Westward Ho	Devon	130	Miss Patterson.
7. Barnstaple	Devon	90	T. Wainwright.
8. Sidcot	Somerset	200	W. F. Miller.
9. Clifton	Gloucester	300	G. C. Griffiths, F.E.S.
10. Penarth	Glamorgan	120	G. A. Birkenhead.
11. Bridgend	Glamorgan	90	H. J. Randall, Junr.
12. Castleton	Monmouth	80	F. G. Evans, F.R.Met.Soc.
13. Newport	Monmouth	300	W. J. Grant, F.R.H.S.
14. St. Arvans	Monmouth	360	Miss M. Peake.
15. St. Davids	Pembroke	220	W. P. Propert, LL.D., F.R.Met.Soc.
16. Aberystwith	Cardigan	30	J. H. Salter, D.Sc.
B			
17. Skibbereen	Cork	30	J. J. Wolfe.
18. Cork	Cork	100	J. Griffin.
19. Killarney	Kerry	100	Ven. Archdeacon Wynne, D.D.
20. Ferns	Wexford	260	G. E. J. Greene, M.A., D.Sc., F.L.S.
21. Ovoca	Wicklow	110	Miss W. F. Wynne.
22. Geashill	King's County	280	Rev. Canon Russell.
C			
23. Bembridge	Isle of Wight	80	C. Orchard, F.R.H.S.
24. Blandford	Dorset	270	J. C. Mansell-Pleydell, F.G.S., F.L.S.
25. Buckhorn Weston	Dorset	290	Miss H. K. H. D'Aeth.
26. Havant	Hants	30	H. Beeston.
27. Botley	Hants	30	Lady Jenkyns.
28. Fordingbridge	Hants	90	S. Bramley.
29. Birdham	Sussex	10	A. J. Nixon.
30. Muntham	Sussex	250	P. S. Godman, F.Z.S.
31. Dover	Kent	150	F. D. Campbell.
32. Chiddingfold	Surrey	230	Vice-Admiral Maclear, F.R.Met.Soc.
33. Winterfold	Surrey	580	R. Turvey.
34. Coneyhurst	Surrey	600	J. Russell.
35. Churt Vicarage	Surrey	350	Rev. A. W. Watson.
35. Churt	Surrey	300	C. Criddle.
36. Oxshott	Surrey	210	W. H. Dines, Pres.R.Met.Soc.
37. Bagshot	Surrey	230	W. Burgess.
38. East Molesey	Surrey	40	Miss R. Follett.
39. Weston Green	Surrey	30	H. T. Potter.
40. Marlborough	Wilts	480	E. Meyrick.
D			
41. Oxford	Oxford	200	F. A. Bellamy.
42. Beckford	Gloucester	120	F. Slade, F.R.Met.Soc.
43. Chesham	Bucks	300	Miss G. Keating.
44. Watford (Oxhey Lane)	Herts	240	G. E. Eland.
44. Watford (The Platts)	Herts	240	Mrs. G. E. Bishop.
44. Watford (Weetwood)	Herts	270	Mrs. J. Hopkinson.
45. St. Albans	Herts	300	H. Lewis.

TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station.	County.	Height above Sea-level.	Observer.
		Ft.	
46. Berkhamsted	Herts	400	Mrs. E. Mawley.
47. Harpenden	Herts	370	J. J. Willis.
48. Ross	Hereford	210	H. Southall, F.R.Met.Soc.
49. Leominster	Hereford	220	J. H. Arkwright.
50. Farnborough	Warwick	520	Miss D. J. G. Prater.
51. Northampton	Northampton	320	H. N. Dixon, M.A., F.L.S.
52. Thornhaugh	Northampton	90	Rev. H. H. Slater.
53. Churchstoke	Montgomery	550	P. Wright, F.R.Met.Soc.
54. Thurcaston	Leicester	250	Rev. T. A. Preston, M.A., F.R.Met.Soc.
55. Beeston	Notts	210	G. Fellows.
56. Hodsock	Notts	60	Miss Mellish, F.R.H.S.
57. Macclesfield	Cheshire	500	J. Dale.
58. Belton	Lincoln	200	Miss F. H. Woolward.
59. Sheffield	Yorks (W.R.)	450	Miss E. F. Smith.
60. Horbury	Yorks (W.R.)	100	The late J. Burton.
61. Ripley	Yorks (W.R.)	240	Rev. W. T. Travis.
E			
62. Broxbourne	Herts	120	Rev. H. P. Waller.
63. Hatfield	Herts	300	T. Brown.
64. Hertford	Herts	140	W. Graveson.
65. Sawbridgeworth	Herts	350	H. S. Rivers.
66. Hitchin	Herts	220	A. W. Dawson, M.A.
67. Odsey (Ashwell)	Cambridge	260	H. G. Fordham.
68. Bocking	Essex	240	H. S. Tabor, F.R.Met.Soc.
69. Wenden	Essex	250	Miss L. Cornwall.
70. Lexden	Essex	90	S. F. Hurnard.
71. Sproughton	Suffolk	30	Rev. A. Foster-Melliar.
72. Market Weston	Suffolk	150	Rev. E. T. Daubeney.
73. Carleton-Forehoe	Norfolk	100	Rev. C. H. Master.
74. Tacolneston	Norfolk	190	Miss E. J. Barrow.
75. Brundall	Norfolk	70	A. W. Preston, F.R.Met.Soc.
76. Brunstead	Norfolk	30	Rev. M. C. H. Bird.
77. Hevingham	Norfolk	...	Major Marsham.
78. Clenchwarton	Norfolk	10	Miss E. M. Stevenson.
79. Peterborough	Northampton	30	J. W. Bodger.
F			
80. Palé	Merioneth	600	T. Ruddy.
81. Alderley Edge	Cheshire	300	W. H. Pepworth.
82. Newby Bridge	Lancashire	210	Miss L. Burton.
83. Ambleside	Westmoreland	260	Miss M. L. Hodgson.
84. Cronkbourne	Isle of Man	110	A. W. Moore and J. Murphy.
85. Orry's Dale	Isle of Man	70	Miss C. M. Crellin.
86. Sulby	Isle of Man	80	H. S. Clarke, F.E.S.
G			
87. Ardgillan	Dublin	210	J. Woodward.
88. Edgeworthstown	Longford	270	J. M. Wilson, M.A.
89. Westport	Mayo	10	J. M. McBride.
90. Loughbrickland	Down	350	Rev. Canon Lett.
91. Saintfield	Down	310	Rev. C. H. Waddell, M.A.
92. Antrim	Antrim	70	Rev. W. S. Smith.
93. Altnafoyle	Londonderry	450	T. Gibson.
94. Ramelton	Donegal	200	Miss K. Swiney.
H			
95. Kirkmaiden	Wigtown	100	Rev. D. R. Williamson.

TABLE II.—List of the Stations with the Names of Observers—*continued.*

Station	County.	Height above Sea-level.	Observer.
		Ft.	
96. Carsethorn	Kirkcudbright	20	S. Arnott.
97. New Galloway	Kirkcudbright	450	T. R. Bruce.
98. Dumfries	Dumfries	70	Miss Cresswell.
99. Jardington	Dumfries	109	J. Rutherford.
100. Moniaive	Dumfries	350	J. Corrie.
101. Helensburgh	Dumbarton	100	Miss Muirhead.
102. Port Ellen	Isle of Islay	10	T. F. Gilmour.
103. Duror	Argyll	20	R. Macgregor.
I			
104. Doddington	Lincoln	90	Rev. R. E. Cole.
105. Thirsk	Yorks (N.R.)	120	A. B. Hall.
106. East Layton	Yorks (N.R.)	570	Mrs. E. O. Maynard Proud.
107. Willington	Durham	280	Miss A. Clench.
108. Durham	Durham	350	R. A. Sampson.
109. Corbridge-on-Tyne	Northumberland	200	A. W. Price.
110. Blyth	Northumberland	20	S. Dunnett.
111. Lilliesleaf	Roxburgh	530	Miss C. M. D. Sprot.
112. Chirnside	Berwick	400	The late C. Stuart, M.D.
J			
113. Edinburgh	Edinburgh	..	W. Evans.
114. Kirriemuir	Forfar	250	T. M. Nicoll.
115. Aberdeen	Aberdeen	40	P. Harper.
116. Newmill	Banff	350	J. Ingram.
K			
117. Invermoidart	Inverness	60	S. M. Macvicar.
118. Roshven	Inverness	40	H. Blackburn.
119. Beauly	Inverness	60	A. Birnie.
120. Dingwall	Ross	10	J. P. Smith, M.D.
121. Inverbroom	Ross	50	Lady Fowler.
122. Watten	Caithness	150	Rev. D. Lillie.

The numbers before the names of the stations refer to their position on the Map of the Stations, Plate I.

gale. *Tiverton* (**A**)—7th. Many plants still in flower, including sweet-peas and 8 varieties of roses. *Sidcot* (**A**)—2nd. 51 different flowers, principally survivals, out in the gardens. *St. Arvans* (**A**)—16th. Roses still in blossom. *Aberystwith* (**A**)—21st. *Daphne Mezereum* in flower. *Skibbereen* (**B**)—2nd. Meadow-sweet again coming into flower. *Bembridge* (**C**)—28th. Geraniums and heliotrope still in flower. *Buckhorn Weston* (**C**)—31st. Found a starling's nest, with young birds in it. *Havant* (**C**)—20th. Gathered 4 ripe strawberries in garden. *Churt Vicarage* (**C**)—13th. Mushrooms gathered on the heath under a tree. 25th. A good many plants still in flower in garden, including roses. *Bagshot* (**C**)—5th. Trees now leafless. *Weston Green* (**C**)—25th. A white *Cydonia japonica* in flower. *Beeston* (**D**)—18th. Still some blooms out on the tea and hybrid tea-roses. 21st. Gathered some primroses in a wood. *Hodsock* (**D**)—About 30 different plants in flower in garden, including a good specimen of Madame Isaac Pereire rose. *Sheffield* (**D**)—26th. Ragwort still in flower. *Brunstead* (**E**)—17th. *Petasites fragrans* in flower. *Clenchwarton* (**E**)—1st. A dish of ripe black plums gathered. 22nd. Some roses still in flower. *Palé* (**F**)

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1901.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic-Hedge-Mustard.	Horse-chestnut.	Hawthorn.	White Ox-eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
A													
Marazion	61	48	...	100	...	...	131	*163*	161	186	...	179	263
Mawnan	69	72	...	93	*132*	135	143	155	163	191	...	...	261
Liskeard	...	56	103	111	...	...	137	...	...	...	...	...	...
Altarnon	59	68	114	123	119	136	146	147	176	190	203	205	271
Tiverton	57	49	97	103	115	124	134	148	156	159	...	...	281
Westward Ho	40	...	...	111	116	125	139	147	168	*199*	...	198	299
Barnstaple	37	56	97	102	111	127	137	145	161	185	194	175	268
Sidcot	29	33	68	110	116	122	139	144	152	...	...	...	246
Clifton	...	...	...	111	...	126	136	...	...	...	...	...	248
Bridgend	60	66	98	115	117	129	141	153	158	172	192	197	273
Castleton	34	38	80	82	113	119	135	148	160	163	201	171	255
Newport	45	56	91	107	108	117	135	136	147	154	...	171	255
St. Arvans	28	...	92	111	117	125	...	...	158	177	...	169	248
St. Davids	...	45	...	113	...	128	150	155	...	176	...	179	...
Aberystwith	40	55	103	96	118	132	135	135	151	166	187	174	252
B													
Skibbereen	34	...	83	90	...	129	138	144	166	191	...	189	...
Cork	10	15	...	...	...	...	...	...	...	...	...	...	...
Killarney	...	...	87	96	121	123	133	145	151	181	186	183	249
Ferns	57	76	82	106	...	133	138	147	157	176	180	182	267
Ovoca	17	47	...	102	...	129	139	146	159	193	...	195	...
Geashill	...	...	89	112	...	128	143	145	170	175	...	...	247
C													
Bembridge	...	...	...	109	119	...	...	...	...	185	...	...	...
Blandford	22	52	84	112	...	*110*	141	135	...	158	172	167	275
Buckhorn Weston	39	65	86	113	103	131	137	143	152	165	...	179	275
Havant	26	69	94	108	115	135	136	141	158	167	...	187	272
Botley	55	91	98	116	131	133	135	143	157	164	198	196	283
Fordingbridge	60	...	104	116	...	128	132	145	...	173	...	165	...
Birdham	...	66	...	104	112	126	138	145	155	169	...	167	281
Muntham	34	83	83	97	116	139	139	145	...	...	...	...	282
Dover	...	...	...	103	...	130	146	...	169	...	...	...	256
Chiddingfold	35	95	93	111	117	122	142	145	160	161	181	187	263
Winterfold	30	...	84	93	...	143	150	153	...	...	196	...	321
Coneyhurst	31	*110*	95	109	...	136	140	154	162	174	171	167	246
Churt Vicarage	26	81	102	113	116	127	137	147	157	164	175	188	...
Churt	17	76	97	112	110	130	*118*	*126*	*124*	177	166	183	240
Oxshott	64	75	102	112	123	131	139	150	...	...	...	...	...
Bagshot	50	...	102	113	...	129	143	134	160	162	...	189	262
East Molesey	...	...	113	112	121	123	138	...	...	...	...	...	...
Weston Green	59	...	104	111	120	127	139	145	166	166	195	171	250
Marlborough	30	59	104	105	116	132	139	153	158	175	176	180	244
D													
Oxford	22	...	...	...	...	...	138	...	...	...	196	...	263
Beckford	33	56	92	94	114	121	128	136	150	159	161	165	259
Chesham	30	...	...	107	127	129	145	138	168	*196*	...	173	277
Watford (Oxhey Lane)	...	98	111	113	...	126	140	137	156	...	204	...	...
Watford (The Platts)	22	85	106	107	113	130	140	156	...	...	...	...	271
Watford (Weetwood)	...	...	...	114	115	125	138	148	149	...	182	...	255

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1901—*continued*.

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic-Hedge-Mustard.	Horse-chestnut.	Hawthorn.	White Ox-eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
Berkhamsted	62	74	110	111	120	132	146	145	155	189	196	186	269
Harpenden	50	72	...	111	116	124	145	151	155	171	210	191	...
Ross	15	54	90	104	108	122	125	...	149	164	191	182	253
Leominster	*95*	...	96	109	...	132	139	...	165	...	...	...	...
Farnborough	22	...	104	113	117	139	139	139	151	187	193	*202*	289
Northampton	66	...	93	117	97	134	140	145	160	172	188	188	248
Thornhaugh	60	65	95	107	124	130	141	...	...	...	...	...	280
Churchstoke	62	70	96	112	124	135	141	...	167	...	209	...	...
Thurcaston	53	72	103	113	115	133	135	151	158	161	189	183	271
Beeston	59	62	...	113	126	134	135	155	167	175	159	...	...
Hodsock	51	73	98	108	116	121	137	150	161	180	186	160	258
Macclesfield	55	82	111	114	139	144	146	156	169	184	185	191	269
Belton	52	70	100	110	120	119	133	...	...	...	...	...	...
Sheffield	56	69	93	...	...	133	146	154	...	181	180	188	289
Horbury	65	56	98	114	131	141	142	...	...	...	...	...	...
Ripley	...	...	...	...	...	134	...	...	...	...	...	...	277
E													
Broxbourne	31	56	...	116	...	...	...	...	...	...	...	...	258
Hatfield	62	77	111	114	...	124	136	142	...	190	191	...	...
Hertford	26	55	93	95	114	125	134	143	157	184	188	188	272
Sawbridgeworth	45	72	107	112	...	134	146	...	152	173	...	175	259
Hitchin	41	62	95	95	...	129	130	139	154	172	...	...	...
Odsey (Ashwell)	...	...	...	...	...	131	141	...	150	...	...	...	265
Bocking	24	73	107	112	116	127	139	153	158	176	...	...	265
Wenden	...	...	...	109	...	134	144	148	161	...	194	...	...
Lexden	59	70	...	114	121	125	136	145	150	168	178	...	...
Sproughton	22	70	91	105	119	127	138	145	157	...	...	...	...
Market Weston	43	71	96	113	118	136	140	...	155	171	179	184	263
Carleton-Forehoe	42	*105*	104	116	117	130	144	155	170	190	186	...	246
Tacolneston	...	68	101	...	...	126	139	...	158	166	...	172	...
Brundall	59	...	98	122	131	134	142	141	168	188	...	176	271
Brunstead	23	70	102	107	118	140	147	152	164	197	200	195	253
Hevingham	...	...	82	...	...	...	151	...	...	...	...	...	...
Clenchwarton	21	32	...	103	123	132	143	...	...	198	...	186	279
Peterborough	44	67	103	87	122	127	129	130	133	...	...	...	295
F													
Palé	59	69	94	114	133	136	144	148	152	182	182	199	274
Alderley Edge	*1*	69	110	...	125	131	...	156	...	*202*	188	...	...
Newby Bridge	...	...	...	...	124	134	136	150	157	181	185	187	254
Ambleside	45	68	72	114	126	140	136	151	...	...	...	...	...
Cronkbourne	...	62	...	...	129	127	140	153	...	...	187	190	278
Orry's Dale	...	66	...	119	...	...	134	...	...	...	...	...	308
G													
Ardgillan	62	62	100	110	...	135	144	152	173	198	...	206	279
Edgeworthstown	73	...	...	116	...	...	...	...	...	...	...	...	...
Westport	49	...	70	115	...	121	142	...	172	...	...	...	258
Loughbrickland	41	71	110	117	...	130	143	161	165	186	...	196	283

TABLE III.—Date (Day of Year) of First Flowering of Plants, 1901—*continued.*

Station.	Hazel.	Coltsfoot.	Wood Anemone.	Blackthorn.	Garlic-Hedge-Mustard.	Horse-chestnut.	Hawthorn.	White Ox-eye.	Dog Rose.	Black Knapweed.	Harebell.	Greater Bindweed.	Ivy.
Saintfield	...	70	96	110	...	137	143	...	...	...	...	...	...
Antrim	62	...	...	...	117	133	141	148	159	...	...	203	278
Altnafoyle	...	77	98	119	...	144	147	...	168	210	...	...	...
Ramelton	101	99	99	120	...	133	138	...	167	...	...	...	...
H													
Kirkmaiden	...	59	...	121	...	135	137	*182*	*184*	...	186	188	...
Carsethorn	...	...	102	...	...	...	140	...	...	...	...	...	...
New Galloway	22	...	110	120	...	140	145	155	164	...	195	...	...
Dumfries	71	71	99	111	130	134	139	142	155	194	194	...	*349*
Jardington	43	82	94	113	...	131	141	...	158	196	188	...	...
Moniaive	...	69	...	...	...	...	151	152	164	200	187	192	286
Helensburgh	59	82	*117*	119	121	134	136	...	...	...	...	...	...
Duror	59	60	77	110	...	...	130	145	151	184	183	...	281
I													
Doddington	51	87	103	113	120	126	137	155	163	...	...	...	257
Thirsk	48	65	95	114	118	128	135	...	149	...	...	...	...
East Layton	33	...	...	112	131	134	148	151	...	...	...	...	...
Willington	68	72	...	113	...	140	142	...	166	...	197	...	...
Durham	64	69	92	...	...	...	147	161	176	204	187	...	...
Corbridge-on-Tyne	60	67	102	115	125	136	144	157	167	190	188	197	282
Blyth	51	63	...	...	130	138	...	164	166	184	176	...	...
Lilliesleaf	...	...	109	117	...	135	147	...	157	...	...	...	...
Chirnside	87	89	*130*	120	155	...	...	...	...	...	...	...	...
J													
Edinburgh	...	68	...	...	...	...	...	...	...	...	...	...	...
Kirriemuir	...	66	...	118	...	...	140	150	165	197	182	...	...
Aberdeen	...	68	96	...	...	146	148	175	184	...	199	...	*305*
Newmill	49	54	112	110	131	138	147	159	168	187	182	201	288
K													
Invermoidart	40	...	110	...	...	...	142	...	...	...	...	...	...
Roshven	...	...	108	...	...	132	139	166	157	199	...	...	292
Beauly	51	70	110	124	...	145	147	157	159	198	199	..	256
Dingwall	62	72	107	119	...	150	153	164	166	...	199	...	287
Inverbroom	20	...	...	...	...	141	146	152	160	213	...	...	...
Watten	...	69	...	...	...	...	155	181	...	210	...	...	...

The dates in *italics* have not been taken into consideration when calculating the means given in Table IV.

—Towards end of month some roses still out on dwarf walls and standards. *Alderley Edge* (F)—26th. Found a wild strawberry partially ripe. *Chirnside* (I)—27th. Lesser celandine in flower.

January 1901.—*Mawnan* (A)—8th. Snow 6 ins. deep. *Sidcot* (A)—2nd. 42 different flowers out in the garden. *Tigroney* (B)—4th. 21 flowers out in garden, including roses, *Cydonia japonica*, mignonette, purple hellebore, and

TABLE IV.—MEAN DATES (DAY OF YEAR) FOR THE FIRST FLOWERING OF 13 PLANTS IN 1901, AND THEIR VARIATIONS FROM THE 10 YEARS' AVERAGE, 1891-1900.

PLANTS.	A England, S.W.			B Ireland, S.			C England, S.			D England, Mid.		
	1901.	Average for 10 Years.	Variation from Average.	1901.	Average for 10 Years.	Variation from Average.	1901.	Average for 10 Years.	Variation from Average.	1901.	Average for 10 Years.	Variation from Average.
Hazel	47	38	+ 9	30	*35*	− 5	39	36	+ 3	46	42	+ 4
Coltsfoot	54	56	− 2	46	*53*	− 7	74	60	+14	71	64	+ 7
Wood Anemone	94	85	+ 9	85	*82*	+ 3	97	84	+13	100	88	+12
Blackthorn	106	91	+15	101	*88*	+13	109	97	+12	110	99	+11
Garlic Hedge Mustard	115	106	+ 9	121	*103*	+18	117	111	+ 6	119	114	+ 5
Horse-chestnut	126	120	+ 6	128	*117*	+11	131	126	+ 5	130	129	+ 1
Hawthorn	138	129	+ 9	138	*126*	+12	139	130	+ 9	139	132	+ 7
White Ox Eye	147	144	+ 3	145	*141*	+ 4	145	141	+ 4	147	148	− 1
Dog Rose	159	153	+ 6	161	*150*	+11	159	156	+ 3	158	159	− 1
Black Knapweed	174	173	+ 1	183	*170*	+13	169	170	− 1	175	176	− 1
Harebell	195	191	+ 4	183	*188*	− 5	181	182	− 1	189	190	− 1
Greater Bindweed	182	183	− 1	187	*180*	+ 7	179	186	− 7	181	191	−10
Ivy	263	263	Av.	254	*260*	− 6	268	269	− 1	269	270	− 1
Mean for the 13 Plants	138	133	+ 5	136	*130*	+ 6	139	134	+ 5	141	139	+ 2

PLANTS.	E England, E.			F England, N.W.			G Ireland, N.			H Scotland, W.		
Hazel	39	38	+ 1	52	43	+ 9	57	52	+ 5	*51*	*54*	− 3
Coltsfoot	65	60	+ 5	67	64	+ 3	76	71	+ 5	*71*	*76*	− 5
Wood Anemone	92	88	+ 4	92	94	− 2	96	87	+ 9	*96*	*100*	− 4
Blackthorn	108	98	+10	116	104	+12	115	99	+16	*116*	*111*	+ 5
Garlic Hedge Mustard	120	111	+ 9	127	124	+ 3	117	*119*	− 2	*126*	*126*	Av.
Horse-chestnut	130	125	+ 5	134	129	+ 5	133	129	+ 4	*135*	*141*	− 6
Hawthorn	140	129	+11	138	136	+ 2	143	138	+ 5	*140*	*144*	− 4
White Ox Eye	145	145	Av.	152	150	+ 2	154	153	+ 1	*149*	*159*	−10
Dog Rose	156	156	Av.	155	160	− 5	167	163	+ 4	*158*	*171*	−13
Black Knapweed	181	178	+ 3	182	186	− 4	198	181	+17	*194*	*188*	+ 6
Harebell	188	187	+ 1	186	184	+ 2	...	*194*	...	*189*	*201*	−12
Greater Bindweed	182	190	− 8	192	190	+ 2	202	*196*	+ 6	*190*	*203*	−13
Ivy	266	263	+ 3	279	281	− 2	275	*274*	+ 1	*284*	*281*	+ 3
Mean for the 13 Plants	139	136	+ 3	144	142	+ 2	144†	138†	+6†	146	*150*	− 4

PLANTS.	I England, N.E.			J Scotland, E.			K Scotland, N.			British Isles.		
Hazel	58	*51*	+ 7	49	*53*	− 4	43	*49*	− 6	46	45	+ 1
Coltsfoot	73	*73*	Av.	64	*75*	−11	70	*71*	− 1	67	66	+ 1
Wood Anemone	100	*97*	+ 3	104	*99*	+ 5	109	*95*	+14	97	91	+ 6
Blackthorn	115	*108*	+ 7	114	*110*	+ 4	122	*106*	+16	112	101	+11
Garlic Hedge Mustard	125	*123*	+ 2	131	*125*	+ 6	...	*121*	...	122	*116*	+ 6
Horse-chestnut	134	*138*	− 4	142	*140*	+ 2	142	*136*	+ 6	133	130	+ 3
Hawthorn	143	*141*	+ 2	145	*143*	+ 2	147	*139*	+ 8	141	135	+ 6
White Ox Eye	158	*156*	+ 2	161	*158*	+ 3	164	*154*	+10	152	150	+ 2
Dog Rose	163	*168*	− 5	172	*170*	+ 2	161	*166*	− 5	161	161	Av.
Black Knapweed	193	*185*	+ 8	192	*187*	+ 5	205	*183*	+22	186	180	+ 6
Harebell	187	*198*	−11	188	*200*	−12	199	*196*	+ 3	188	*192*	− 4
Greater Bindweed	197	*200*	− 3	201	*202*	− 1	...	*198*	....	189	*192*	− 3
Ivy	270	*278*	− 8	288	*280*	+ 8	278	*276*	+ 2	272	*272*	Av.
Mean for the 13 Plants	147	*147*	Av.	150	*149*	+ 1	149*	*143**	+6*	143	141	+ 2

* For 11 Plants. † For 12 Plants.

\+ indicates the number of days later than the average date.
− ,, ,, ,, earlier ,, ,,
Av. ,, average date (1891-1900).
The dates in *italics* are approximate averages.

pink hepatica. *Birdham* (C)—16th. Saw a wild primrose with 6 flowers. *Berkhamsted* (D)—6th. The last rose bloom destroyed by frost, or one month later than the average date for the previous 15 years, and later than in any year since 1885. *Clenchwarton* (E)—5th. *Daphne Mezereum* in flower.

FEBRUARY.—*Altarnon* (A)—18th. Rooks building. 28th. House sparrow fledged. *Bridgend* (A)—19th. Rooks building. 20th. Partridges paired. *Aberystwith* (A)—24th. Frog spawn first seen. *Geashill* (B)—18th. Gathered 2 wild primroses. *Bembridge* (C)—9th. *Prunus pissardi* in flower. *Chiddingfold* (C)—5th. Many branches of evergreens broken with the wet snow. *Churt Vicarage* (C)—4th. Heavy fall of snow, which did considerable damage to trees. *Clenchwarton* (E)—17th. Water-wagtail seen. *Palé* (F)—During a deep fall of snow the kale brocoli, etc., had to be covered with nets to keep the wood-pigeons from eating them.

MARCH.—*Altarnon* (A)—2nd. Trees blown down by high winds. *Tiverton* (A)—6th. Marsh marigold in flower. *Birdham* (C)—6th. Frog spawn first seen. *Churt Vicarage* (C)—The tea-roses, which had escaped injury from winter frosts, much injured by those of this month. *Harpenden* (D)—4th. Rooks building. 25th. Eggs in thrush's nest found frozen together. *Leominster* (D)—30th. The early chestnut tree on Aylestone Hill in leaf. *Peterborough* (E)—Cold winds and frost from 25th to 28th checked vegetation and nipped many plants and trees which had budded.

APRIL.—*St. Arvans* (A)—11th. Blackcap first seen. 22nd. Willow-wren first heard. *Tigroney* (B)—8th. Cowslip in flower. *Coneyhurst* (C)—24th. Sand-martin first seen. *Churt Vicarage* (C)—9th. Wryneck first heard. *Beckford* (D)—2nd. Date of wood-anemone the latest since 1891. *Watford* (*Oxhey Lane*) (D)—14th. Wild primrose in flower. *St. Albans* (D)—1st. Wryneck first heard. *Beeston* (D)—18th. Willow-wren first heard. 22nd. A few days of genial weather has caused a great change in the appearance of the country. *Lexden* (E)—After 19th vegetation advanced rapidly. *Brunstead* (E)—25th. House-martin first seen. *Clenchwarton* (E)—28th. House-martin first seen. *Palé* (F)—Peacock and tortoiseshell butterflies unusually numerous. *Alderley Edge* (F)—21st. House-martin first seen. *Ambleside* (F)—19th. Frog spawn first seen. *Westport* (G)—24th. Martin first seen. *Moniaive* (H)—4th. Sand-martin first seen. *Inverbroom* (K)—29th. Wild geese went north.

MAY.—*Altarnon* (A)—6th and 7th. Snow fell. Cold till 23rd, when warm nights caused farm and garden crops to start all at once into growth. 30th. A dry three weeks, following another fairly dry period, has favoured the turf and peat harvest, which began at an unusually early date. *Barnstaple* (A)—237 species of wild flowers were recorded during the month, the average for the eight preceding Mays being 248. *Sidcot* (A)—Very poor show of hawthorn blossom this year. 28th. Shallow-rooted plants suffering much from drought. *Geashill* (B)—A poor show of apple blossom. *Botley* (C)—An unusual number of orange-tipped butterflies. *Chiddingfold* (C)—22nd. Leaf-roller caterpillars on oaks in great numbers. *Churt* (C)—25th. First swarm of bees. *Bagshot* (C)—By the close of the month the lawns began to look quite brown. *Berkhamsted* (D)—Scarcely any apple blossom, and some trees without any flowers at all. *Macclesfield* (D)—Very backward spring. Until 7th very few trees in leaf. *Lexden* (E)—Our local house-martins returned in greatly diminished numbers. *Sproughton* (E)—18th. A disastrous frost. Potatoes, dahlias, and runner beans injured and a large majority of Royal Sovereign strawberry blooms destroyed. *Market Weston* (E)—20th. Potatoes cut by frost. 29th. Much damage done to foliage of trees and garden produce by hail. *Carleton-Forehoe* (E)—9th. Last fieldfare seen. *Brunstead* (E)—24th. First swarm of bees. *Palé* (F)—Flowering trees and shrubs, such as hawthorn, horse-chestnuts, gorse, etc., very full of bloom. *Cronkbourne* (F)—4th. Killed 17 queen wasps.

TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1901.

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
A											
Marazion	14	93	109	...	...	282	101	...	110	152	175
Mawnan	1	105	108	...	...	286	...	...	110	142	172
Liskeard	2	105	110	...	154	264	53	...	106	130	114
Altarnon	1	108	110	...	118	281	54	73	111	141	132
Westward Ho	11	108	111	...	150	257	83	108	102	*166*	125
Sidcot	...	100	107	110	...	304	75	...	...	...	...
Clifton	...	...	112	125	...	...	...	...	111	117	...
Penarth	...	...	...	...	...	...	111	...	72	...	...
Bridgend	23	104	119	...	...	270	71	126	110	...	111
Castleton	24	98	107	...	138	291	64	112	111	115	143
Newport	31	95	107	121	128	287	40	70	92	106	127
St. Arvans	38	109	108	113	...	...	53	117	112	145	165
St. Davids	37	102	112	...	...	273	107	...	115	134	162
Aberystwith	2	107	116	...	...	305	68	110	110	122	153
B											
Skibbereen	3	102	116	...	...	305	33	113	116	114	166
Cork	12										
Killarney	...	104	117	...	...	285	97	106	103	124	...
Ferns	1	107	103	...	...	284	68	127	107	125	130
Ovoca	18	96	115	...	...	289	68	118	111	116	121
Geashill	...	104	...	...	...	272	57	122	107	124	178
C											
Bembridge	1	101	110	100	...	314	71	...	107	...	...
Blandford	2	108	103	110	111	299	57	122	71	110	173
Buckhorn Weston	2	...	...	...	...	283	59	...	...	...	...
Havant	21	94	111	100	131	315	11	76	107	144	178
Botley	22	108	111	112	137	302	...	110	110	133	169
Fordingbridge	*59*	...	109	108	...	296	22	111	...	124	...
Birdham	...	99	111	105	144	314	56	85	81	135	177
Muntham	20	107	108	100	140	311	33	116	95	118	...
Dover	...	112	...	...	...	298	...	...	...	...	...
Chiddingfold	1	108	105	100	134	284	1	112	115	134	148
Winterfold	23	104	105	105	...	293	...	80	...	...	...
Coneyhurst	...	113	101	102	152	284	59	100	59	...	...
Churt Vicarage	23	107	108	113	136	278	59	101	108	133	161
Churt	7	109	107	108	130	299	10	76	112	128	153
Oxshott	40	109	108	111	...	...	...	...	...	...	...
Bagshot	19	111	109	112	131	284	59	110	109	133	...
East Molesey	20	113	113	112	...	...	...	...	109	...	...
Weston Green	2	109	110	107	158	280	51	100	96	...	...
Marlborough	42	95	110	118	138	...	...	...	129	124	159
D											
Beckford	21	103	108	109	144	289	21	115	115	131	159
Chesham	...	105	108	...	...	281	...	133	...	134	..
Watford (Oxhey Lane)	...	110	110	107	...	278	...	...	111	...	...
Watford (The Platts)	5	108	106	110	...	*250*	...	...	110	...	...
Watford (Weetwood)	...	100	111	112	...	283	59	110	97	134	...
St. Albans	19	109	95	101	...	...	...	...	...	...	...
Berkhamsted	46	99	108	111	132	270	59	112	109	132	181

TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1901—*continued.*

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange-Tip Butterfly.	Meadow-Brown Butterfly.
Harpenden	21	98	110	110	...	...	...	112	98	148	...
Ross	3	110	111	120	...	273	63	117	112	124	113
Leominster	...	105	109	117	124	292	...	128	114	...	...
Farnborough	3	98	111	98	*107*	308	60	110	108	125	163
Thornhaugh	4	107	105	109	123	286	52	92	109	128	...
Churchstoke	*62*	109	110	...	*173*	285	107	111	119	127	168
Thurcaston	...	111	...	...	...	...	...	...	110	133	...
Beeston	17	110	118	...	134	...	83	113	112	...	...
Hodsock	22	109	111	112	126	291	53	112	113	132	...
Macclesfield	24	120	121	...	...	280	...	...	...	...	...
Belton	19	109	115	109	126	...	56	110	107	133	140
Sheffield	1	...	124	...	...	267	...	...	...	...	...
Horbury	3	117	113	...	...	...	...	113	111	...	...
Ripley	...	111	111	...	...	267	...	112	110	...	...
E											
Broxbourne	16	98	106	96	133	286	43	85	97	...	...
Hatfield	57	113	112	102	128	...	...	...	...	...	...
Sawbridgeworth	2	103	111	110	112	296	59	111	108	132	168
Hitchin	...	106	111	102	140	...	...	...	...	...	...
Odsey (Ashwell)	...	108	*127*	111	147	285	...	...	...	...	...
Bocking	...	...	112	112	...	...	...	...	...	...	...
Wenden	*61*	112	111	111	...	...	92	*190*	...	127	...
Lexden	...	109	111	108	142	285	70	107	109	130	...
Sproughton	4	109	111	111	128	...	59	87	113	141	...
Market Weston	2	109	113	109	143	283	53	117	113	127	184
Carleton-Forehoe	2	106	113	108	134	302	56	115	111	134	155
Tacolneston	...	...	...	...	...	296	21	99	...	...	...
Brundall	...	109	108	109	...	...	...	...	...	...	...
Brunstead	24	109	109	...	140	284	70	112	107	151	153
Hevingham	23	109	103	104	...	...	...	...	...	...	...
Clenchwarton	...	111	104	...	...	302	68	95	111	142	...
Peterborough	6	101	122	124	...	290	55	117	106	...	...
F											
Palé	22	109	111	...	123	273	59	114	121	134	187
Alderley Edge	...	104	110	...	135	271	71	110	123	...	...
Newby Bridge	...	...	...	...	129	...	...	...	...	...	181
Ambleside	45	114	121	...	132	...	45	116	...	140	69
Cronkbourne	17	99	112	...	...	285	30	113	111	107	125
Orry's Dale	6	113	109	...	...	...	58	122	112	...	...
Sulby	21	108	116	...	...	282	...	90	108	...	141
G											
Ardgillan	3	97	114	...	...	282	...	99	114	124	133
Edgeworthstown	17	104	115	...	...	293	70	...	110	...	...
Westport	19	113	118	...	...	277	...	*221*	...	...	...
Loughbrickland	18	109	110	...	...	277	49	...	111	121	170
Saintfield	17	113	116	...	138	...	...	...	123	128	...
Antrim	21	100	116	...	119	270	67	114	...	122	...
Altnafoyle	19	114	123	...	...	...	...	124	120	125	189
Ramelton	3	108	111	...	138	287	37	123	...	...	114

TABLE V.—Date (Day of Year) of Song and Migration of Birds, and First Appearance of Insects, 1901—*continued*.

Station.	Song.	Migration.					Insects.				
	Song-Thrush first heard.	Swallow first seen.	Cuckoo first heard.	Nightingale first heard.	Flycatcher first seen.	Swallow last seen.	Honey Bee.	Wasp.	Small White Butterfly.	Orange Tip Butterfly.	Meadow Brown Butterfly.
H											
Kirkmaiden	27	129	122	...	...	...	74	164	113	...	171
Carsethorn	...	113	121	...	...	...	...	110	101	...	...
New Galloway	23	110	111	...	...	272	63	...	111	...	...
Dumfries	...	114	118	...	139	...	...	126	121	...	189
Jardington	20	111	119	...	...	...	...	107	121	...	180
Moniaive	...	108	116	...	...	259	...	*201*	122	...	184
Helensburgh	17	132	118	...	...	...	81	124	128	...	...
Port Ellen	8	...	...	...	...	...	*2*	...	...	...	...
Duror	46	111	115	...	...	285	67	135	121	...	...
I											
Thirsk	12	101	121	...	...	...	83	...	109	...	...
East Layton	23	110	...	...	147	...	57	111	...	128	...
Willington	...	113	...	...	152	...	...	134	...	...	...
Durham	46	113	132	...	118	268	72	124	...	144	199
Corbridge-on-Tyne	52	117	128	...	...	273	61	125	...	...	...
Blyth	49	105	138	...	...	...	...	...	...	...	...
Lilliesleaf	42	124	124	...	...	...	69	124	132	...	74
Chirnside	45	110	114	...	135	...	69	119	130	...	...
J											
Edinburgh	3	114	117	...	...	...	...	112	...	...	...
Kirriemuir	...	111	119	...	...	285	68	...	...	...	...
Aberdeen	22	129	133	...	...	240	103	136	124	...	...
Newmill	...	118	121	...	...	273	62	124	122	159	163
K											
Invermoidart	41	...	119	...	...	...	...	114	...	...	...
Roshven	...	111	121	...	...	...	...	122	123	...	...
Beauly	62	110	123	...	146	265	58	114	132	...	...
Dingwall	38	132	139	...	...	263	51	122	125	...	...
Inverbroom	...	...	128	...	...	...	...	124	135	...	...
Watten	...	...	154	...	...	...	69	...	133	...	108
Mean Dates for the British Isles in 1901	19 Jan. 19th	108 Apl. 18th	113 Apl. 23d	109 Apl. 19th	135 May 15th	284 Oct. 11th	61 Mar. 2nd	112 Apl. 22nd	111 Apl. 21st	130 May 10th	152 June 1st
Mean Dates for 1891-1901	Jan. 27th	Apl. 17th	Apl. 21st	Apl. 21st	May 13th	Oct. 13th	Feb. 26th	Apl. 10th	Apl. 16th	May 7th	June 8th

The dates in *italics* have not been taken into consideration when calculating the means for the British Isles.

Jardington (H)—Queen wasps exceedingly numerous. *Moniaive* (H)—10th. House-martin first seen. *Aberdeen* (J)—The dates for horse-chestnuts and hawthorn the earliest yet recorded here. *Newmill* (I)—21st. First swarm of bees.

June.—*Mawnan* (A)—13th. Grass first cut for hay. *Bridgend* (A)—15th. Everywhere a magnificent show of elder blossom. 19th. Hay first cut. *St. Arvans* (A)—More blackbirds and thrushes than usual this year. *Churt Vicarage* (C)—14th. Vegetable marrows destroyed by frost in lower part of parish.

Description of Crop.	England.						Scotland.			Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H W.	J E.	K N.	B and G S. and N.	
Wheat	U. Av.	U. Av.	U. Av.	Av.	Av.	U. Av.	Av.	Av.	...	Av.	U. Av.
Barley	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	Av.	Av.	O. Av.	U. Av.
Oats	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Corn Harvest began, average Date	215 (Aug. 3)	210 (July 29)	215 (Aug. 3)	214 (Aug. 2)	217 (Aug. 5)	223 (Aug. 11)	229 (Aug. 17)	230 (Aug. 18)	241 (Aug. 29)	226 (Aug. 14)	222 (Aug. 10)
Beans	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	Av.	Av.	...	Av.	U. Av.
Peas	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	...	Av.	...	Av.	U. Av.
Potatoes	Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	O. Av.	Av.	O. Av.	O. Av.	U. Av.
Turnips	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Av.	Av.	O. Av.	U. Av.	U. Av.
Mangolds	U. Av.	U. Av.	U. Av.	U. Av.	Av.	Av.	O. Av.	O. Av.	...	O. Av.	U. Av.
Hay (Permanent Pastures)	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Much U. Av.
Hay (Clover, etc.)	Much U. Av.	Much U. Av.	Much U. Av.	Much U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	Much U. Av.

The variations from the average for the above crops have been obtained from the returns which appeared in the *Agricultural Gazette*, July 22–August 12, 1901.

TABLE VII.—Estimated Yield of Fruit Crops in 1901.

Description of Crop.	England.						Scotland.	Ireland.	British Isles.
	A S.W.	C S.	D Mid.	E E.	F N.W.	I N.E.	H, J, and K W. E. and N.	B and G S. and N.	
Apples	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Pears	U. Av.	U. Av.	U. Av.	U. Av.	O. Av.	Av.	U. Av.	Av.	U. Av.
Plums	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.	U. Av.
Raspberries	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Currants	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Gooseberries	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.
Strawberries	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.	O. Av.

Symbols:—O. = Over. U. = Under. Av. = Average. This Table has been compiled from returns which appeared in the *Gardeners' Chronicle*, Aug. 3, 1901.

TABLE VIII.—Variations from the Average in Mean Temperature, Rainfall, and Sunshine, 1900-01.

Winter 1900-1.

Temperature.

Months.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
December	+5·8	+4·3	+6·3	+6·8	+5·8	+6·5	+4·5	+6·0	+7·0	+5·8	+4·3
January	−0·2	−0·4	+0·4	−0·6	+0·6	0·0	+0·4	+0·4	+0·4	+0·2	+1·2
February	−3·3	−4·0	−3·5	−2·5	−4·0	−2·8	−1·8	−2·0	−2·3	−2·0	−1·3
Winter	+0·8	0·0	+1·1	+1·2	+0·6	+1·2	+1·0	+1·5	+1·7	+1·3	+1·4

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
December	+2·0	+2·9	+0·5	+0·3	−0·5	+0·8	+1·6	+4·5	−0·6	+1·6	+5·4
January	+0·4	−0·1	−0·4	+0·7	−0·4	−0·5	+0·1	−2·0	0·0	−0·3	−1·2
February	−1·2	−1·3	−0·5	−0·8	−0·1	−0·8	−0·6	−2·0	+0·1	−0·4	−1·6
Winter	+1·2	+1·5	−0·4	+0·2	−1·0	−0·5	+1·1	+0·5	−0·5	+0·9	+2·6

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
December	−19	−10	−10	−7	−2	−7	−14	−13	−5	−4	−1
January	+5	0	+11	−6	+4	−3	+11	−6	−15	−18	−7
February	+8	−12	−16	−20	−24	−11	−15	+6	−15	−10	0
Winter	−6	−22	−15	−33	−22	−21	−18	−13	−35	−32	−8

Spring 1901.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
March	−2·8	−3·0	−3·3	−3·0	−3·3	−2·5	−2·3	−1·8	−1·8	−1·5	−1·0
April	+1·0	−0·3	+0·8	+1·5	+1·3	+1·0	−0·8	−0·3	+1·5	−0·3	+0·3
May	+1·4	+1·0	+0·6	+1·0	+0·8	+1·6	+2·0	+2·2	+1·2	+1·4	+2·8
Spring	−0·1	−0·8	−0·6	−0·2	−0·4	0·0	−0·4	0·0	+0·3	−0·1	+0·7

Rain.

	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
March	−0·2	−0·3	+0·3	+0·2	+0·3	+0·1	0·0	−0·3	−0·1	−0·2	−0·5
April	+1·4	+0·7	+0·4	+0·4	+0·7	+0·1	+1·1	+1·7	−0·4	0·0	+0·9
May	−1·5	−0·9	−0·9	−1·3	−0·9	−1·0	−0·5	−1·1	−0·3	0·0	−1·4
Spring	−0·3	−0·5	−0·2	−0·7	+0·1	−0·8	+0·6	+0·3	−0·8	−0·2	−1·0

Sunshine.

	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
March	−18	0	−49	−23	−38	+9	−4	+5	+3	−12	+12
April	+26	+30	+40	+46	+45	+49	+37	+38	+67	+33	+19
May	+77	+85	+61	+65	+42	+82	+78	+57	+41	+48	+60
Spring	+85	+115	+52	+88	+49	+140	+111	+100	+111	+69	+91

\+ indicates above the average, − below it.

TABLE VIII.—VARIATIONS FROM THE AVERAGE—*continued.*

SUMMER 1901.

Temperature.

MONTHS.	Eng. S.W.	Ire. S.	Eng. S.	Eng. Mid.	Eng. E.	Eng. N.W.	Ire. N.	Scot. W.	Eng. N.E.	Scot. E.	Scot. N.
	°	°	°	°	°	°	°	°	°	°	°
June . .	0·0	−1·5	−0·3	−0·5	−0·3	−1·0	−2·0	−1·8	+0·3	−0·8	−0·8
July . .	+3·0	+2·6	+3·0	+4·2	+2·4	+3·6	+2·4	+3·6	+3·4	+4·2	+3·8
August . .	+0·3	+0·3	+1·3	+1·3	+1·3	+0·5	0·0	0·0	+2·0	+0·5	+1·0
Summer . .	+1·1	+0·5	+1·3	+1·7	+1·1	+1·0	+0·1	+0·6	+1·9	+1·3	+1·3
					Rain.						
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
June . .	−0·2	−0·1	−1·0	−1·1	−1·0	−0·5	+0·5	+0·8	−0·7	−0·1	+0·7
July . .	−1·2	−2·3	+0·2	+1·4	−1·0	−1·4	−2·3	−2·0	−0·7	−1·5	−1·2
August . .	−0·4	−0·4	−0·1	−0·5	−0·7	−0·1	+0·7	+0·6	−0·2	+0·4	+0·3
Summer . .	−1·8	−2·8	−0·9	−0·2	−2·7	−2·0	−1·1	−0·6	−1·6	−1·2	−0·2
					Sunshine.						
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
June . .	− 9	−33	+46	+40	+59	+30	−17	+24	+45	+51	−10
July . .	+11	−21	+47	+16	+33	+42	−25	+21	+38	+30	+28
August . .	+ 3	+22	+43	+35	+39	+48	+27	+41	+51	+26	+24
Summer . .	+ 5	−32	+136	+91	+131	+120	−15	+86	+134	+107	+42

AUTUMN 1901.

Temperature.

	°	°	°	°	°	°	°	°	°	°	°
September .	+1·5	+1·3	+1·3	+1·3	+1·8	+1·8	+1·3	+2·3	+2·3	+2·3	+3·0
October . .	+1·0	+0·6	+1·8	+1·0	+1·4	+1·4	0·0	−0·2	+0·8	0·0	+0·4
November .	−2·8	−0·8	−2·8	−2·8	−2·0	−2·0	+0·8	−0·5	−1·3	−0·5	−0·3
Autumn . .	−0·1	+0·4	+0·1	−0·2	+0·4	+0·4	+0·7	+0·5	+0·6	+0·6	+1·0
					Rain.						
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
September .	−0·5	+2·2	−0·4	−1·1	−1·2	−2·2	+0·9	+0·2	−1·1	−1·1	−1·4
October . .	−2·4	−0·4	−1·3	−1·5	−0·9	−1·0	+0·3	+0·6	−0·9	−0·9	0·0
November .	−2·7	−1·0	−2·1	−1·0	−0·5	+1·2	+1·0	+0·2	+1·5	−0·2	−1·0
Autumn . .	−5·6	+0·8	−3·8	−3·6	−2·6	−2·0	+2·2	+1·0	−0·5	−2·2	−2·4
					Sunshine.						
	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.	hrs.
September .	−30	−32	−18	−10	−16	+13	−23	0	0	+ 2	+11
October . .	−11	0	+ 7	+12	+20	+18	+19	+ 3	+10	+ 8	+16
November .	+12	− 2	+17	− 7	− 1	+ 8	− 6	− 2	+15	+ 8	+ 4
Autumn . .	−29	−34	+ 6	− 5	+ 3	+39	−10	+ 1	+25	+18	+31

The above Table has been compiled from the variations from the mean given in the *Weekly Weather Reports* issued by the Meteorological Office.

TABLE IX.—Supplementary Observations in 1901.

PLANTS.

Winter Aconite.

Station.	District.	Date.
St. Arvans	A	Dec. 29 (1900)
Aberystwith	A	Jan. 25.
Churt Vicarage	C	,, 17.
Berkhamsted	D	,, 17.
Carleton-Forehoe	E	,, 3.
Clenchwarton	E	,, 5.
New Galloway	H	,, 19.
Thirsk	I	,, 23.
Watten	K	Feb. 19.

BIRDS.

Wheatear (first seen).

Marazion	A	March 28.
Bridgend	A	April 5.
Bembridge	C	March 31.
St. Albans	D	April 3.
Chirnside	I	,, 25.

Chiff-Chaff (first heard).

Mawnan	A	March 23.
Tigroney	B	April 10.
St. Albans	D	,, 2.
Alderley Edge	F	,, 14.
Loughbrickland	G	,, 19.
Antrim	G	,, 11.

Corncrake (first heard).

Station.	District.	Date.
Bridgend	A	May 13.
Geashill	B	April 23.
Watford (Oxhey Lane)	D	May 12.
Beeston	D	April 27.
Alderley Edge	F	,, 27.
Sulby	F	,, 19.
Westport	G	,, 21.
Loughbrickland	G	,, 25.
New Galloway	H	May 6.
Corbridge-on-Tyne	I	April 28.
Chirnside	I	,, 29.
Newmill	J	,, 23.
Inverbroom	K	May 9.
Watten	K	,, 13.

Swift (First Seen).

Marazion	A	May 20.
Mawnan	A	,, 10.
Chiddingfold	C	,, 14.
Churt	C	,, 6.
St. Albans	D	,, 7.
Sheffield	D	,, 15.
Odsey (Ashwell)	E	,, 16.
Lexden	E	,, 16.
Alderley Edge	F	,, 13.
Westport	G	,, 13.
Antrim	G	April 29.
New Galloway	H	May 15.
Chirnside	I	,, 14.
Newmill	J	,, 10.

19th. Lawns parched. Dahlias and potatoes blackened by frost in lower part of parish. *Bagshot*—(C)—Meadow grass thin and brown. *Oxford* (D)—1st. Hay harvest began. *Beckford* (D)—6th. First ear of wheat out of sheath. *Watford* (*Oxhey Lane*) (D)—11th. Haymaking began. *Harpenden* (D)—The cold winds, together with the drought, proved very trying to vegetation. In this neighbourhood large areas of oats and barley were not more than 6 ins. high. 10th. First ear of wheat out of sheath, or one day later than its average date in the previous 9 years. 19th. Potato haulms, and also scarlet runner beans and dwarf beans, cut down by frost, especially in the low-lying parts of the parish. *Farnborough* (D)—Very little blossom on apples, but pears and cherries flowering profusely. *Beeston* (D)—11th. Lawns very brown. Foxgloves not nearly so tall or luxuriant as usual. *Hodsock* (D)—Old hawthorn bushes very full of blossom. *Market Weston* (E)—Great absence of bloom on apples, pears, plums, and hawthorn. *Carleton-Forehoe* (E)—Very few cuckoos or butterflies. 3rd. First swarm of bees. *Tacolneston* (E)—Almost no blossom on the apple trees. *Brunstead* (E)—Very few house-martins this year. Less laburnum blossom than I remember here for 10 years. *Newby Bridge* (F)—27th. Haymaking began—a good crop. *Cronkbourne* (F)—22nd. Hay harvest began. *Sulby* (F)—25th.

TABLE X.—Leafage and Defoliation of Lime Trees in the "Garden" of the Bank of England, London, E.C.

Year.	Appearance of the First Speck of Green.	Trees quite bare of Leaves.	Year.	Appearance of the First Speck of Green.	Trees quite bare of Leaves.
1888	April 20	October 26	1895	March 23	October 31
1889	March 30	,, 21	1896	,, 24	,, 17
1890	,, 31	,, 28	1897	,, 23	,, 25
1891	,, 18	,, 29	1898	April 5	,, 27
1892	,, 30	,, 24	1899	,, 4	,, 20
1893	,, 14	,, 20	1900	,, 6	,, 29
1894	,, 27	,, 22	1901	,, 9	,, 26

The above unique set of observations has been sent me by Mr. A. Brewin. The observations have been taken with great care each year for the last 14 years by his friend Mr. Pike, who states that "about the end of May these trees in the heart of the city are a sight worth seeing. For the past 3 years a pair of wood-pigeons have made the largest tree their home for a short time in the spring, and have built a nest in which eggs have been laid and sat upon but never hatched out."

Saw a thorn hedge which for over a mile was completely divested of its leaves by the larvæ of *H. padella*, so that it presented quite a burnt appearance. *Kirkmaiden* (H)—14th. The Scotch Burnet rose in flower along the shore. *Moniaive* (H)—10th. Pears, apples, and plum trees, and horse-chestnuts suffered severely from biting cold winds. The tender succulent stems of the potatoes were bruised and blackened almost beyond recognition. *Lilliesleaf* (I)—Profuse blossom on broom and gorse.

July.—*Mawnan* (A)—29th. Corn first cut. *St. Arvans* (A)—White butterflies numerous. 30th. Corn first cut. *Chiddingfold* (C)—Oak foliage very luxuriant. *Churt Vicarage* (C)—Lawns perfectly brown early in the month. *Bagshot* (C)—Caterpillars very numerous on cabbages. *Watford* (*The Platts*) (D)—11th. Lawns dried up. *Hodsock* (D)—20th. Corn first cut. *Macclesfield* (D)—Pastures quite brown and straw of oats only from 12 to 18 ins. in length. *Clenchwarton* (E)—29th. Harvest began. *Cronkbourne* (F)—29th. Harvest began. *Moniaive* (H)—By the end of the month the hay harvest was practically over. 20th. Corncrake last heard. *Newmill* (J)—Butterflies numerous, especially whites and meadow-brown.

August.—*Mawnan* (A)—7th. Last swift seen. 24th. Corn harvest practically over. *St. Arvans* (A)—10th. Bees have made very little honey this year. *Geashill* (B)—Blackbirds very destructive in gardens. But few butterflies or earwigs this summer. *Botley* (C)—An unusual number of butterflies this summer. *Chiddingfold* (C)—Wasps very numerous. Aphides of all kinds very numerous this summer. *Bagshot* (C)—A great plague of wasps. *Oxford* (D)—1st. Harvest began. *Beckford* (D)—1st. Wheat harvest began. Wasps very numerous. Thousands of blossoms on one myrtle. *Northampton* (D)—The heat and drought caused a short flowering season for most summer plants. *Beeston* (D)—12th. Wasps numerous. *Hodsock* (D)—10th. Severe hailstorm, which did much damage to foliage, flowers, and fruit in gardens. 27th. Harvest finished. *Ripley* (D)—9th. Last swift seen. *Broxbourne* (E)—Potatoes and other vegetables suffered greatly from drought. *Carleton-Forehoe* (E)—Acorns abundant. 2nd. Wheat first cut. *Clenchwarton* (E)—Wasps extremely numerous. 31st. Harvest ended. *Newby Bridge* (F)—10th. Severe thunder-

storm. Trees struck by lightning. *Cronkbourne* (F)—Wasps very numerous. *Jardington* (H)—Wasps fairly numerous. 1st. Corn harvest began, exceptionally early. *Moniaive* (H)—Corn harvest began in the second week, an unusually early date for the district, and was almost completed by the end of the month. *Duror* (H)—A plague of wasps. *Corbridge* (I)—Wasps very numerous. Very few butterflies this year. *Newmill* (J)—The forest trees free from insect pest attack this year. 12th. Swift last seen. 20th. Corn harvest began—straw short and thin. *Inverbroom* (K)—30th. Wild geese went south.

September.—*Mawnan* (A)—All autumn flowers late. *Killarney* (B)—Scarcely any wasps. Gooseberry caterpillars and aphides numerous. 22nd. Laburnum in flower. *Birdham* (C)—Hawkmoths unusually numerous this year. *Churt Vicarage* (C)—26th. Wasps very numerous. Blackberries large and abundant. The yield of hops said to be the largest for 30 years. *Bagshot* (C)—Mushrooms and blackberries very plentiful. *Berkhamsted* (D)—Mushrooms very numerous. *Farnborough* (D)—The best honey harvest for 4 or 5 years. Wasps and earwigs numerous and did much damage to wall fruit. *Market Weston* (E)—A bad year for honey. Many fields of beans have been ruined by aphis. *Tacolneston* (E)—Chimney swallows unusually few all this year. 2nd. Many trees are losing their leaves in dry and crowded situations. *Brunstead* (E)—1st. Harvest generally finished in the shortest time on record. But few holly-berries. *Palé* (F)—Wasps very destructive to fruit. *Jardington* (H)—Harvest all over by the beginning of the month.

October.—*Altarnon* (A)—Acorns and horse-chestnuts very abundant. Woodcock and snipe scarce. *Skibbereen* (B)—There were but few swallows during the whole of October. *Tigroney* (B)—13th. Dahlias killed. *Chiddingfold* (C)—Autumnal tints remarkably fine. *Coneyhurst* (C)—14th. Sand-martin last seen. *Churt Vicarage* (C)—No berries on mountain-ash this year. 14th. Foliage on trees as green as in August. 20th. Dahlias killed by frost. *Churt* (C)—Chestnuts very plentiful. *Bagshot* (C)—26th. Dahlias killed by frost. *Watford* (*The Platts*) (D)—26th. Dahlias killed by frost. *Northampton* (D)—Strawberries ripened fairly well in some gardens about the middle of the month. *Hodsock* (D)—12th. Dahlias, begonias, and sweet-peas still very good. *Macclesfield* (D)—Autumn tints very fine at end of month. *Lexden* (E)—6th. A severe gale did some damage to old trees. *Palé* (F)—Autumnal tints most brilliant. *Jardington* (H)—A nice crop of autumn grass. Very little potato disease. *Moniaive* (H)—Acorns and horse-chestnuts were abundant, but hazel nuts scarce. 12th. Frost of sufficient severity to strip the walnut trees. *Corbridge-on-Tyne* (I)—10th. Dahlias killed by frost. *Dingwall* (K)—19th. Dahlias killed by frost.

November.—*Mawnan* (A)—2nd. Gathered a wild rose. 4th. Nasturtiums flowering now better than in the summer. 9th. 46 different flowers out in our garden. 15th. Dahlias killed by frost, very early for this district. *Altarnon* (A)—7th. Fieldfare first seen. *Tiverton* (A)—1st. A ripe wild strawberry gathered. 29th. Hawthorn blossoms gathered. *Sidcot* (A)—5th. Dahlias killed by frost. *Castleton* (A)—2nd. A solitary house-martin seen. *St. Arvans* (A)—6th. An unusually sharp frost blackened all the flowers in the garden. *Bembridge* (C)—10th. Dahlias killed. *Havant* (C)—13th. Dahlias killed. *Churt* (C)—11th. Fieldfare first seen. *Bagshot* (C)—30th. About half the leaves remain on the oak trees. *Tacolneston* (E)—4th. Fieldfares first seen. 5th. Dahlias killed. *Brunstead* (E)—2nd. Fieldfare first seen. *Clenchwarton* (E)—9th. Redwings and fieldfares first seen. *Palé* (F)—3rd. Dahlias killed by frost. *Newby Bridge* (F)—4th. Dahlias killed by frost. *Cronkbourne* (F)—12th. Heavy gale, 8 large Austrian pines blown down. *Ardgillan* (G)—12th. Gale from north-north-east blew down 745 trees, some of 200 years' growth.

DISCUSSION.

Mr. F. C. Bayard said that he was struck by the remark that apple-blossom had been very scanty. In his own neighbourhood at Wallington the blossom was very fine, and the crop a larger one than usual. The quality, however, was not good, the maggot causing great destruction. On the other hand, pears were scarce, although the blossom was as plentiful as that of the apple. He quite agreed with Mr. Mawley as to the sunny character of the year, and he thought the records would prove it to be the sunniest since 1887. The hay crop in the Croydon district was fairly good.

Mr. A. Brewin said that of course Mr. Mawley must go by the general character of the observations to obtain a true average, and not take individual cases. At Twickenham pears were so numerous that it was difficult to get rid of them, and there was also a large crop of apples.

Mr. Baldwin Latham remarked that his observations in his own garden bore out Mr. Bayard's statement as to the quantity of apples and scarcity of pears, but it was not so in other parts of the country. In many parts of South Wales and Devonshire there was a great scarcity of apples. The whole country must be taken into consideration in order to obtain reliable data. They were greatly indebted to Mr. Mawley for the great labour and time he spent on the preparation of the Report year after year, and he hoped that he would long continue to carry on the work, for as it proceeded the record became more and more valuable.

Mr. C. Harding remarked that Mr. Mawley rather deplored the increasing size of the tables, but he himself thought that was rather a point for congratulation than otherwise. In his opinion the real value of the Report consisted in these tables. In his own garden at Tulse Hill he had a very large crop of pears on some trees, but very few on others. He thought his success was due to a sheltered position. He had also noticed that roses were exceedingly plentiful last year, although the quality was not good. He would like to ask if the tail end of winter being severe—although the earlier part had been very mild, as was the case in the year under discussion—would account for the poorness of blossom and general backwardness of the season. The exceptional dryness of the year, too, there being only three wet months out of twelve, must have had some effect on vegetation, especially when coming after several years of deficient rainfall. He had recently been analysing the rainfall at Greenwich for the past sixty years, and in the last nine years, 1893 to 1901, had noticed as many as eight wet Decembers.

Mr. R. Inwards remarked that Mr. Mawley was careful to exclude hearsay remarks, and had, to his knowledge, made a journey of several miles on one occasion to verify a statement as to the appearance of the wood anemone. Dr. Lee formerly was in the habit of giving a shilling to the first boy on his estate who heard the earliest cuckoo note. He thought that plan was not to be commended, as it gave rise to some remarkably early reports on the subject.

Dr. H. R. Mill inquired if the seasons were practically simultaneous all over the country, or if there was a well-marked change from south to north. He was greatly struck last May, when travelling from Christiania to the Hook of Holland, by the opening beech trees along the line. These all seemed to be in the same state of progress, and were probably merely a section of what must be happening for hundreds, or even thousands of miles to the east. It was known in a general way that the seasons are more backward as we travel north, but he would like to know if the retardation were greater than the interval between a late and an early season at any one point. He thought the Report was a clear general statement of the weather and its influence on plant life,

and desired to associate himself with the expression of thanks to Mr. Mawley for continuing this important work.

Mr. E. MAWLEY in reply thanked those present for their generous reception of the Report. The yield of apples in 1901 varied considerably in different parts of the country, and even fairly good as well as very scanty crops were here and there to be met with in the same locality. But according to the numerous returns sent in last year to the *Gardeners' Chronicle*, the average yield was poor in all the Meteorological Office districts. The same might be said of the hay crop which, although variable, was in every district below average. During the recent summer droughts in England the conditions have been more favourable to farm and garden crops in Scotland and Ireland. The inhabitants of towns did not appreciate summer rains, whereas for dwellers in the country there was seldom enough rain to satisfy them during the growing period of the year. He did not think that the tail end of the winter being cold had much effect in retarding vegetation in the spring, for no sooner was the frost out of the ground than rapid progress was made after a week or so of warm weather. Hot, dry weather in summer, if long continued, retarded growth in the same way that cold did at other periods of the year. On all the observation forms observers were warned against spurious notes of the cuckoo. The farther north we went the later, as a rule, was the flowering of plants; but he did not think that the average difference between the extreme districts in the British Isles would be as much as the extreme differences, taking a number of years, in any one locality. He could not understand why the trees mentioned by Dr. Mill should have been in the same state of leafage over such a large tract of country as he had described, unless the season happened to be a very exceptional one.

Meteorology in New South Wales, 1901.—During the year 1901 the Meteorological Service has been steadily maintained in this State. The number of first order stations is 31, and of second order stations, 61. The telegraph stations, which have only a rain-gauge and report the state of the weather and rain, have been increased by 8 during the year, and now number 198 stations (including the first and second order). Five inland stations have anemometers recording continuously direction of wind and velocity in miles. Also one at Sydney, recording on a scale, 1 hour to the inch, the direction and the velocity of the wind, and the rain.

The *Rain and River Report* for 1899 has been printed. That for 1900 is ready to go to press, and that for 1901 is in preparation. *Current paper* No. 6 is ready for press. The number of first and second order stations remains as they were, but rain stations are steadily increasing, and now number 196. The forecast is issued at 10 a.m. and 9 p.m. The evening forecasts are widely distributed over the State, and are much appreciated by the public.

Efforts are made to instruct the Pastoralist. There are good opinions about the importance of Meteorological work, and very many persons are keenly interested, and take means by telephone to get the forecast sent to them every evening.—H. C. RUSSELL, *Government Astronomer.*

"LA LUNE MANGE LES NUAGES."—A NOTE ON THE THERMAL RELATIONS OF FLOATING CLOUDS.

By W. N. SHAW, F.R.S., F.R.Met.Soc.

[Read March 19, 1902.]

IT is always difficult to be sure that different persons are in agreement in identifying meteorological phenomena, and I will therefore state in a few words the conditions to which, according to my notions, the French proverb refers.

A single layer of drifting fleecy clouds—detached Stratus—is rendered visible by the illumination of the Moon not very long after sunset. The illumination not only shows the clouds, but shows that they are diminishing, and finally the Moon is left in possession of an unusually clear sky. If this is not a correct description of the phenomena to which the proverb refers, it describes a state of things for which I desire to suggest a physical explanation which is not without interest.

I will put the matter in another way:—A floating cloud, a finite mass of air carrying water particles, is losing heat by radiating into space through the clear air above it more heat than it receives from the earth beneath; the water globules will, in consequence of this loss of heat, evaporate, and the cloud will vanish. The converse of this proposition may be stated in slightly different form, thus: A floating cloud is receiving heat from the sun above and the earth beneath, and in consequence of this gain of heat condensation will take place, and the cloud become thicker.

These statements are paradoxical, and to exaggerate the apparent paradox it is only necessary to point out that, as the cloud consists of saturated air, evaporation means a rise of temperature, condensation a fall of temperature; for evaporation implies more vapour in the gaseous form, which is only possible at a higher temperature, and *vice versâ*. So we may reduce the proposition from the Meteorological form to a more conventionally physical one, and say that the abstraction of heat from a floating mixture of air and water will cause elevation of its temperature, or briefly, will warm the mixture, whereas the addition of heat will cool it.

The explanation of the apparent paradox is a simple one, as may be seen from the following consideration:—

Suppose a mass of moist air at the surface of the earth to be warmed: it rises, and in consequence expands adiabatically and cools. Suppose that it rises just sufficiently high to form a cloud: then if it had been less warmed it would not have risen high enough for condensation to take place. If it had been more warmed it would have risen higher, and a cloud might have been formed even denser than in the first case. Supplying less heat before the condensation took place is, of course, equivalent to removing some after the first condensation occurred; one side of the proposition follows, therefore, at once, if we can assume that the cloud was formed by the adiabatic cooling of rising air. It is, of course, the changes of pressure incidental to differences of level (due to

change of density) which produce the paradoxical thermal effects. But although this mode of treating the problem shows well enough that a cloud which is losing heat by radiation into space will grow warmer and disappear, it does not give any satisfactory proof that the cloud would grow thicker if the sun shone upon it.

The course of events for a floating cloud can, however, be very clearly followed out by means of Hertz's diagram of thermal lines for moist air, which is published in vol. i. of the *Meteorologische Zeitschrift*, and is reproduced in Waldo's *Modern Meteorology*. The diagram represents the state of a mixture of air and water under varying conditions of pressure and temperature, the lines of reference being set out according to the logarithms of the pressure and of the temperature from absolute zero. Since the pressure scale is logarithmic, equal intervals along it correspond approximately to equal steps of height in the atmosphere. The adiabatic lines for different stadia, and the lines of saturation for given percentage composition, enable all the changes in thickness of a cloud under varying quantities of heat to be followed. The diagram is approximate only, but sufficiently nearly accurate to indicate satisfactorily the changes that take place in floating cloud. For this purpose we must add to the diagram a line indicating the relation of temperature and height, or pressure, for the atmosphere in equilibrium, *i.e.* the line of temperature gradient. This, of course, is a variable line, depending on the condition of the upper atmosphere for the time being; but supposing, for example, the temperature gradient to be uniform, and equal to 0°·5 C. for every hundred metres (as given by Berson's figures for heights up to 2000 metres), we get a line across the diagram nearly straight, and dropping one degree in temperature for every 200 metres of height, as shown at the base of the diagram. The direction of the line being fixed, its position on the diagram must be defined by drawing it in the proper direction through a selected point representing the condition of a floating cloud. We may take a water cloud just above the freezing point, say at 5° C., at 1200 metres height. Through the point identified by these conditions we can draw the equilibrium line of temperature, and know that, whatever be the initial state of a mass of air, it will rise or sink, following the changes which Hertz's diagram represents, until the equilibrium line is reached. In Fig. 1 certain parts of Hertz's diagram are reproduced, and the equilibrium line is added. The point A represents the state of the floating cloud at 5° C. at 1200 metres, saturated with about 6·2 grammes of water-vapour per kilogramme of mixture, as indicated by its position with reference to the saturation lines which are dotted in the figure. QAQ′ is the adiabatic line for saturated air. SAS′ the saturation line for 6 grammes of moisture per kilogramme of mixture; the dotted lines parallel to this on either side represent the saturation lines for 7 grammes and 5 grammes respectively. EAE′ represents the equilibrium or temperature gradient line. This line is a little less steep than the adiabatic lines for saturated air, but decidedly more steep than the saturation lines. If we start from the point A on the equilibrium line, representing the condition of the floating cloud, the addition of heat (supposing the cloud always to rise until it recovers its equilibrium) means that the point will travel along the equilibrium line AE to the left; the temperature will fall, since the slope is downward; and, since

the equilibrium line is steeper than the saturation line, the point will pass into the part of the diagram where saturation requires less moisture—in other words, condensation will take place. Abstracting heat, on the other hand, means travelling along the equilibrium line in the opposite direction, AE′; the air passes into a region where more water is required for saturation. Hence evaporation takes place. Since the slope of the equilibrium line is upward, the temperature rises.

It is interesting to note that the result of warming a mass of floating air depends upon the temperature gradient for height of the air in which it floats. If the law of fall of temperature with height were the adiabatic law, a mass of air at the foot warmed ever so little above its surroundings would rise without limit. An inversion of temperature, on the other hand,

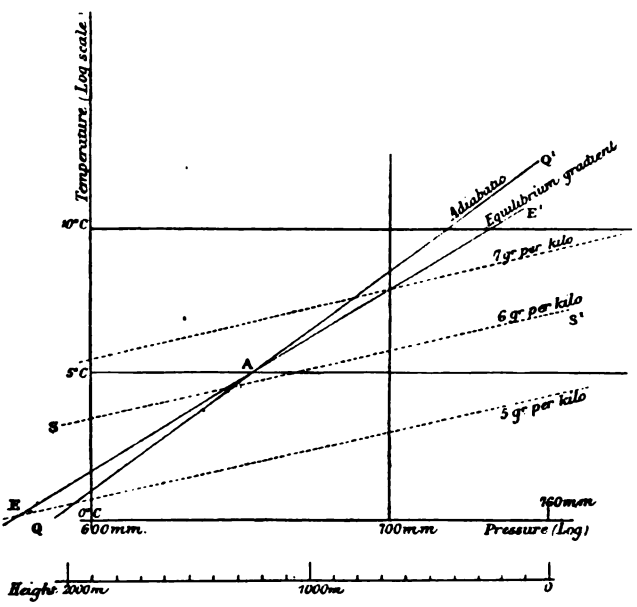


FIG 1.

would at once prevent any rise taking place, or speedily arrest it. A temperature gradient exactly parallel to the saturation line would indicate the conditions under which a cloud might receive or lose heat and change its temperature without any evaporation or condensation taking place.

It thus appears that, except in cases of an "inversion of temperature," or of a zero temperature gradient, meteorologists, in considering the properties of floating masses of air, have to consider that the ordinary relations between the increase of heat and increase of temperature must be reversed.

It is, of course, possible to suggest other physical explanations for the disappearance of clouds in accordance with the French proverb, and my excuse for suggesting one which may seem fanciful is, that it brings into prominence certain physical relations which are certainly real and are not generally noticed.

I ought to add a word with regard to the conveying of heat to a cloud

by radiation. I have spoken as though the distribution took place throughout the cloud, and not, as would possibly appear more likely, at the upper or lower surface only. Although the confining of the addition of heat to the outer portions only would not affect the physical principles involved, I may mention in defence of these views that the clouds in question are generally very thin and very translucent, so that every part of the cloud is illuminated by the Moon's rays, and consequently is exposed to other sources of radiation.

The extent to which clouds can absorb or emit radiation has not yet been ascertained, but there is no question that they are more effective radiators and absorbers than clear air.

It will be noticed that I have passed over any suggestion that the lunar radiation itself adds heat to the cloud. Possibly it does, but the amount of heat so gained must in any case be small compared with that lost by radiation to the rest of a clear sky, so that any effect of direct radiation from the Moon may be quite properly disregarded.

The effect of difference of temperature gradient upon the increase or diminution of density of floating clouds with accession of heat, is one that may have many other applications than the one here referred to. It would seem, for example, to furnish a criterion for determining whether the action of the sun upon mist lying on the ground would result in dispersion of the mist, or the lifting of the mass as a cloud either directly upwards, or possibly creeping along a hillside till the top is reached.

The observations of temperature gradient by the ascent of kites would probably afford facilities for testing by observation the effects which have here been theoretically indicated.

Addendum—February 3, 1902.

Since the above was written I have put together an arrangement of apparatus whereby the conditions applicable in the case of a floating cloud can be experimentally realised. The essential condition of the arrangement is, that the communication of heat to a limited mass of air shall result in a diminution of the pressure of the air, just as the communication of heat to a floating cloud results in the diminution of pressure as the cloud rises to a higher level. In the apparatus the necessary condition is secured by using a movable cistern of mercury to close the vessel containing the moist air. For this purpose the air is conveniently contained in a globe, G (Fig. 2), surmounting a vertical tube open at the bottom. The globe with its vertical tube is fixed in a stand, and the open bottom of the tube dips into the mercury in the cistern, C. The mercury cistern rests upon one end of a board, B, about five feet long, which is balanced upon a knife-edge, E, the mercury and its containing vessel being counterpoised by suitable weights, P (about 6 lbs.) at the other end of the board. The mercury vessel is thus supported by one arm of a rough balance, and, since all the weights on the balance are above the point of support, the balance, regarded apart from the effect of the elasticity of the air in the globe, is unstable. The instability is the essential feature of the arrangement, and is largely exaggerated by mounting a heavy mass of lead, L, on an iron stand attached to the middle of the balancing board, so that the lead is about 5 feet above the board.

The globe is provided with tubular apertures, not shown in the figure, to allow it to be filled with saturated and nucleus-laden air at pleasure; but during an experiment these apertures are closed. It is also provided with wires, W, led through an indiarubber bung, and connected in the interior of the globe by means of a fine platinum wire, to allow heat to be supplied to the air at pleasure by passing an electric current through the fine wire.

When the globe has been filled with suitable air, and the apertures closed, any motion of the board diminishes or increases the pressure in the interior by the motion of the mercury vessel. The increase or diminution of pressure tends to resist the motion of the board, and by adjusting the positions of the counterpoise and the lead weight, the arrangement can be made to balance just within the limits of stability, when the elasticity of the enclosed air is taken into account. When this

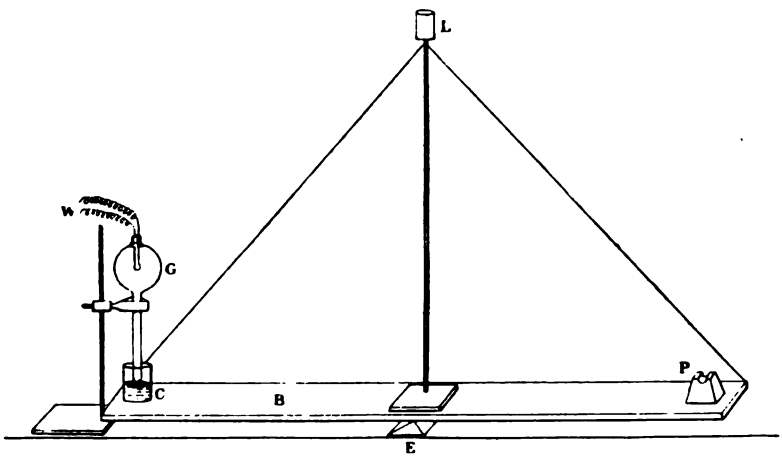


FIG 2.

adjustment is made, it is clear that a slight motion of the board in the direction of increasing the volume of the enclosed air throws over the lead weight towards the same side as the globe, and brings to bear a largely increased moment of forces tending to continue the expansion; so that the ultimate expansion resulting from any cause tending to depress the balance on the globe side produces a rarefaction depending on the degree of dynamical instability of the balance. Such a cause arises when the air in the globe is slightly warmed by passing a current through the wire. If the mercury vessel were fixed, the heating would produce increase of pressure in the cloud space, and consequently increase of pressure on the mercury surface supported by the board. As, however, the balanced vessel is movable, the balance comes over, and then the dynamical instability causes expansion, determined not solely by the amount of heat which originated the motion, but by the loads on the balance and their position.

The success of the experiment, for the demonstration of the production of a cloud—*i.e.* a diminution of temperature—on heating, depends upon the proper selection of the area of the tube in comparison with the

volume of the globe. I have found a four-inch globe with a one and a half inch tube give completely satisfactory results. The counterpoising weights are about seven pounds on each side, and the lead weight with iron stand supporting it perhaps fifteen pounds. Under these conditions, with the globe filled with saturated air and closed, and the mercury vessel properly counterpoised, the commencement of heating at once determines a depression of the board on the globe side, a rarefaction corresponding to about three-quarters of an inch of mercury and an abundant cloud. The experiment can be repeated with the same air, after readjusting the balance, until the exhaustion of nuclei for the deposit of globules makes the arrangement insensitive. Its activity can always be restored by refilling it with suitable air.

The degree of instability of the balance corresponds to the temperature gradient for height in nature. I have not yet formed an estimate of the temperature gradient to which my arrangement of the apparatus would correspond. But the analogy between the two is formally correct, and with a slight modification of the apparatus the equivalent temperature gradient could be determined. It would be still more strikingly clear to the eye if the globe and tube were attached to the balance and the mercury reservoir fixed. In that case the globe of air would indeed rise with increase of heat, and the arrangement would become simply an apparatus for multiplying the effect of the rise, a rise of two inches with my apparatus being equivalent to a rise of about five hundred feet in nature. It would thus become a comparatively simple means of conducting in the laboratory operations which really take place on a large scale in nature.

DISCUSSION.

THE PRESIDENT (Mr. W. H. DINES) said they were much indebted to Mr. Shaw for his interesting paper and experiment. It appeared impossible at first sight to suppose that warming a mixture of air and vapour should produce a cloud; it was perhaps more correct to say adding heat instead of warming, since the mixture really became cooler; but any way, there could be no doubt about the actual result. Mr. Shaw had given them an ocular demonstration of the fact that lighting a small electric lamp in a glass bulb might, under certain conditions, cool the air in the bulb sufficiently to produce condensation. The supply of heat lifted the mixture to a higher adiabatic line, which adiabatic it followed downwards to a lower temperature until the position of equilibrium was reached. To what extent a mass of air rising or falling in the atmosphere really followed an adiabatic curve was an interesting point on which Mr. Shaw had not entered. He thought, too, that the paper was valuable in another way, viz., because it showed the great use which theoretical considerations might be turned to account in explaining meteorological phenomena. Mr. Shaw had foreseen the result that would follow entirely from the theoretical side, and had then verified it by an experimental proof.

Dr. H. R. MILL remarked that the paper was an extremely interesting one. He himself remembered seeing the phenomenon on Loch Fyne fifteen years ago, for several evenings in succession. Immediately after sunset the air became much colder and the sky clouded over, but in the course of an hour or so the pall of cloud slowly melted away, leaving the sky in brilliant starlight. The formation and vanishing of the cloud lasted probably about two hours. He

was considerably puzzled by the occurrence at the time, but Mr. Shaw's explanation and experiment made the matter seem quite simple and almost obvious. He would like to ask if the thermal conditions as regards change of temperature on exposure to radiation in a condensed cloud would be the same as in the surrounding air, or if the cloud would heat and cool more rapidly.

Capt. D. WILSON-BARKER hardly thought the experimental conditions were quite the same as those in Nature, though he quite recognised the light thrown on a difficult subject by such means. He, too, would like to ask if the changes taking place in the cloud were the same as in the surrounding air? He was not aware that the French had a proverb bearing on this matter, but knew very well that it was a regular sailor's expression, for they say that "the moon scoffs the clouds." He thought this arose a good deal from the fact that the conditions during the night were often more stable than during the day, and this was frequently shown by the less amount of cloud seen then. The effect of the moon was to make this more visible. He thanked Mr. Shaw for his very interesting paper; and the beautiful experiment, even if not absolutely convincing, went a long way towards demonstrating a possible explanation of the phenomenon.

Mr. W. N. SHAW in reply said he was not prepared to give a definite answer as to whether the radiating or absorbing power of a cloud was greater or less than that of the surrounding air. At the same time he would point out that the existence of the cloud showed some difference of properties between the cloud and the air in which it floated, and as between the two he would expect the cloud to have greater power of absorbing heat from the sun on account of the repeated reflexions affording more opportunities for absorption than transmission without reflexion.

Climate of Manila.—A brief pamphlet has been issued by the Manila Observatory giving some climatological data concerning the weather of Manila. The accompanying Table gives the monthly results based upon the 16 years' observations 1883-98, except those for rainfall which are for the 34 years 1865-98.

Months.	Atmospheric Pressure.			Temperature.			Mean Relative Humidity.	Rainfall.	
	Mean.	Highest.	Lowest.	Mean.	Highest.	Lowest.		Mean.	Greatest.
	in.	in.	in.	°	°	°	%	in.	in.
January . .	29·97	30·21	29·71	77·0	93·0	62·1	77·7	1·19	7·33
February .	29·98	30·19	29·68	77·7	95·7	61·0	74·1	0·41	1·50
March . .	29·95	30·15	29·65	80·4	95·9	63·3	71·7	0·74	2·36
April . .	29·90	30·06	29·67	82·9	99·0	66·0	70·9	1·14	1·72
May . . .	29·86	30·03	29·38	83·3	100·0	71·1	76·9	4·20	6·57
June . . .	29·85	30·02	29·59	82·0	97·0	70·9	81·5	9·62	9·95
July . . .	29·82	30·00	29·43	80·8	94·8	70·0	84·9	14·57	11·42
August . .	29·83	30·02	29·53	80·8	94·3	69·1	84·4	13·87	8·92
September .	29·83	30·03	29·23	80·4	93·7	70·5	85·6	14·93	13·23
October . .	29·88	30·06	29·45	80·4	94·8	68·7	82·6	7·54	6·77
November .	29·90	30·16	29·27	79·0	92·1	64·9	81·6	5·13	7·11
December .	29·96	30·16	29·54	77·4	91·9	60·3	80·7	2·13	3·54
Year .	29·89	30·21	29·23	80·2	100·0	60·3	79·4	75·46	13·23

SYMONS MEMORIAL MEDAL.

(Frontispiece and Plate II.)

THE first presentation of the Symons Memorial Gold Medal was made at the Annual General Meeting of the Society on January 15, 1902, the recipient being Dr. Alexander Buchan, F.R.S.

In presenting the Medal to Dr. Buchan, the President read the following extract from the Minutes of the Council, which sets forth the reasons for the award :—

"ALEXANDER BUCHAN, M.A., LL.D., F.R.S., was proposed for the Symons Medal on account of his life-long labour in the cause of meteorological science, and the leading part which he has taken in the development of British Meteorology during more than forty years.

"Dr. Buchan has been Secretary of the Scottish Meteorological Society since 1860, and a member of the Meteorological Council since 1887. He was largely concerned in securing the erection of a high-level Observatory on Ben Nevis, and in discussing the results obtained, which are now practically ready for publication.

"Amongst the larger discussions of data carried out by Dr. Buchan were the 'Report on Atmospheric Circulation' founded on the work done during the voyage of *The Challenger;* the article 'Meteorology' in the *Encyclopædia Britannica*, ninth edition, and papers on the normal Pressure, Temperature, and Rainfall of the British Isles.

"He is the author of *The Handy Book of Meteorology*, 1867 (second edition 1868); *Introductory Text-book of Meteorology*, 1871; and editor of the meteorological volume of *Bartholomew's Great Physical Atlas*, 1899.

"In addition to these he has published numerous papers of high scientific value in the *Journal* of the Scottish Meteorological Society, and in other publications."

A portrait of Dr. Buchan is given on the Frontispiece.

The Gold Medal is 2¼ inches in diameter, and weighs 5 ounces. The obverse bears an impression of the portrait of Mr. Symons, with the inscription: GEORGE JAMES SYMONS, F.R.S., 1838-1900, and the reverse a representation of the Tower of the Winds at Athens, with the inscription ROYAL METEOROLOGICAL SOCIETY.

Illustrations of the obverse and reverse of the Medal are given on Plate II.

THE SYMONS MEMORIAL MEDAL.

OBVERSE.

REVERSE.

Quart. Journ. Roy. Met. Soc. vol. xxviii. pl. ii.

It was proposed by Mr. R. BENTLEY, seconded by Mr. R. INWARDS, and resolved: "That the most cordial thanks of the Royal Meteorological Society be communicated to the President and Council of the Institution of Civil Engineers for having granted the Society free permission to hold its Meetings in the rooms of the Institution."

The PRESIDENT having read the Minute of Council respecting the award of the Symons Memorial Medal, presented the Medal to Dr. ALEXANDER BUCHAN, F.R.S. (p. 102).

The PRESIDENT then delivered an Address on "THE ELEMENT OF CHANCE IN RELATION TO VARIOUS METEOROLOGICAL PROBLEMS" (p. 53).

It was proposed by Mr. R. H. SCOTT, F.R.S., seconded by Mr. W. N. SHAW, F.R.S., and resolved: "That the thanks of the Society be given to Mr. W. H. DINES for his Address, and that he be requested to allow it to be printed in the *Quarterly Journal*."

The Scrutineers declared the following gentlemen to be the Officers and Council for the ensuing year:—

PRESIDENT.

WILLIAM HENRY DINES, B.A.

VICE-PRESIDENTS.

CAPT. MELVILLE WILLIS CAMPBELL HEPWORTH, F.R.A.S.
RICHARD INWARDS, F.R.A.S.
BALDWIN LATHAM, M.Inst.C.E., F.G.S.
EDWARD MAWLEY, F.R.H.S.

TREASURER.

CHARLES THEODORE WILLIAMS, M.A., M.D., F.R.C.P.

SECRETARIES.

FRANCIS CAMPBELL BAYARD, LL.M.
HUGH ROBERT MILL, D.Sc., LL.D., F.R.S.E., F.R.G.S.

FOREIGN SECRETARY.

ROBERT HENRY SCOTT, M.A., D.Sc., F.R.S.

COUNCIL.

RICHARD BENTLEY, F.L.S., F.R.G.S.
CAPT. WARREN FREDERICK CABORNE, C.B., F.R.G.S., F.R.A.S.
CAPT. ALFRED CARPENTER, R.N., D.S.O., F.Z.S.
RICHARD HENRY CURTIS.
HENRY NEWTON DICKSON, B.Sc., F.R.S.E., F.R.G.S.
WILLIAM ELLIS, F.R.S., F.R.A.S.
CHARLES HAWKSLEY, Pres.Inst.C.E.
JOHN HOPKINSON, F.L.S., F.G.S., Assoc.Inst.C.E.
HENRY MELLISH, J.P., F.R.G.S.
SIR JOHN WILLIAM MOORE, M.D., F.R.C.P.I.
WILLIAM NAPIER SHAW, M.A., F.R.S.
CAPT. DAVID WILSON-BARKER, F.R.S.E., F.R.G.S.

February 19, 1902.

Ordinary Meeting.

WILLIAM HENRY DINES, B.A., in the Chair.

EDWARD HUGH CULLEY, M.A., School House, Monmouth;
ARTHUR ELPHINSTONE HEPBURN, Soberton Rectory, Bishop's Waltham;
JOHN HEPPER, J.P., Clareville, Headingley, Leeds;
EDWARD HODDINOTT, Stratton St. Margaret, Wilts;
JOHN AUGUSTUS JUST, 116 East Castle Street, Syracuse, N.Y., U.S.A.;
RICHARD FRANK RAND, M.D., Sterndale, Royston Park, Hatch End;
MATTHEW ALEXANDER ROBINSON, Richmond Street, Londonderry;
JAMES LIDDERDALE SCOTT, F.R.A.S., Shanghai;
CHARLES FREDERICK WOOD, 26 Linden Gardens, Chiswick; and
NORMAN WRIGLEY, 10 Brunswick Gardens, W.,
were balloted for and duly elected Fellows of the Society.

The following communication was read:—

"REPORT ON THE PHENOLOGICAL OBSERVATIONS FOR 1901." By EDWARD MAWLEY, F.R.H.S. (p. 69).

CORRESPONDENCE AND NOTES.

Meteorological Notes in South Africa.—Major H. A. Cummins, of the Royal Army Medical Corps, has given in *Science Gossip* for November 1901, some interesting meteorological notes which he made while on service in South Africa. In 1900 he trekked from near Orange River to Pretoria, *vid* Jacobsdal, Paardeberg, and Bloemfontein. Living during the greater part of the time in the open air, he had an opportunity of observing the local climatic conditions and various other matters. The following extracts from these "Notes" will be of interest:—

"My attention was particularly arrested by the character of the local storms, and I noted them as they occurred. While at De Aar, towards the end of January, strong breezes and whirlwinds were, I may say, constant, carrying the dust and sand from the ground which had been worn by excessive traffic, and covering our food and kit. It was almost impossible to see without the aid of a pair of goggles to protect the eyes from the dust. At Modder River on February 4 we encountered a sandstorm which lasted from 6 P.M. to 9 P.M. This storm, unaccompanied by rain, must have been a couple of miles in diameter—in fact a glorified "dust devil." The term "dust devil" is used in South Africa to denote a whirlwind, from one yard to twenty yards or so in diameter, which carries a pillar of dust or sand in its vortex.

"On March 19, when travelling to Bloemfontein across the veldt with a few men and an ambulance waggon, I was caught in a heavy thunderstorm. One man had his hand on the brake of the waggon, and at the moment the vehicle was struck by lightning, giving the man a shock severe enough to cause temporary loss of power in his arm. One can scarcely realise the brilliancy of the jagged lightning as it appears to rush from the sky to the ground, accompanied by the roar and rattle of the thunder. Soldiers were at times severely burnt by the lightning, or even killed. I have been told by residents in the country that when on "trek" it is not uncommon for a whole span of oxen to be killed by one flash of lightning.

"During the hot weather the air in the Pretoria valley became heated and

dry, and appeared to act as a buffer against storms which approached, deflecting them on to the surrounding hills. The drier the air, the greater this effect. The storms in South Africa are very remarkable phenomena. Frequently of small diameter, they blow with terrific violence, and travel over large stretches of country. They vary in size from the "dust devil" to a storm a couple of miles in diameter. I am told that their violence is at times sufficient to whirl sheets of corrugated iron into the air as if they were pieces of paper. I have never encountered any equal in power to this, but I have seen many trees levelled to the ground by them in Pretoria. The storms which visited Pretoria during my residence there varied in size from 100 yards to about a mile in diameter. Usually they were accompanied by thunder and rain, the whirlwind coming in front and raising a pillar of dust, sand, papers, branches of trees, etc., which were sometimes carried a couple of hundred feet or more into the air. In the dry weather the whirl pillar may or may not be accompanied by rain and thunder. The lightning from the dry storms is said to be very dangerous, as the lightning discharge is very intense. The whirl pillar appears to be at an angle of 80° or 90°, with the ground sloping backwards from its line of progression to the cloud. The usual speed appeared to be from seven to nine miles an hour.

"The large quantity of rain which falls, in a short time enlarges the water courses to an enormous extent. One could scarcely credit the fact that the large gulleys and rivers which have only a few gallons of water running through them in dry weather can, in the course of a couple of hours or less, become roaring torrents. The rain has not time to soak into the ground, so that the quantity of surface water to be carried off, is enormous. The veldt for miles looks like a lake, but as soon as the storm has passed the sun comes out and rapidly dries up the water which has not run away through the spruits, while in the low-lying damp ground the frogs croak and the insects sing."

Prize Competition for Apparatus for measuring Wind Pressure.—The German Government offers three prizes of the value of £250, £150, and £100 for the three best types of wind-pressure gauge. The technical conditions which must be fulfilled are as follows:—(1) The pressure gauge must be arranged so as to show the strength of the resultant force of the wind pressure on flat surfaces and on bodies, including the suction action on the lee side, in such a manner that the observations taken can be used for statistical purposes. (2) It is desirable that the pressure gauge should show the direction of the measured resultant force against the measured surface, clearly and unmistakably. (3) The pressure gauge must show the strength of the wind pressure automatically, so that an uninterrupted record of its force and duration may be obtained. (4) Any instrument in which is taken into consideration the velocity of the wind in arriving at the results will be thereby debarred from entering into the competition.

The other regulations to be observed are as follows:—(1) The competition is open to all persons at home and abroad. (2) Competitors must fix at their own cost their instruments or working models thereof at the Deutsche Seewarte, Hamburg, and furnish the drawings and calculations necessary to explain their working and construction. The whole must be accompanied in each case by a distinguishing word or mark, and must reach the Deutsche Seewarte before April 1, 1903. Anything sent after that date will not be considered. The distinguishing word or mark must also be placed in a separate envelope, together with the address to which the instrument is to be returned. In the case of foreigners, the address of a representative in Germany must be given. A second envelope must contain the name of the inventor. This envelope will only be opened should the inventor be a prize-winner. (3) In addition to the

three prizes already mentioned a further prize of £150 will be given to the inventor of the instrument which, after a prolonged test, shall be adopted by the Government for its own use. Before this prize is awarded the inventor will have to state how many of his instruments he is prepared to deliver at the price named by him. (4) The plans of the instruments for which prizes are awarded will become the property of the Deutsche Seewarte. Competitors are recommended to take out patents for their designs before sending them in for competition.—*The Times*, March 11, 1902.

The "De Witte Typhoon," August 1-6, 1901.—It will be remembered that in the last No. of the *Quarterly Journal* we gave a reproduction of a barographic trace taken on board the s.s. *Laisang* during this period. The Rev. Louis Froc, S.J., of the Zi-Ka-Wei Observatory, Shanghai, has collected and discussed the meteorological facts relating to this typhoon, which he describes as above, because the Russian steamer *Finanzminister De Witte*, foundered during the storm.

We will quote a few extracts from Father Froc's Report.

"*Extent.*—The typhoon of August 3 was a very extensive storm, reaching at the same time to points very distant from each other. The object of the following particulars is only to give precision to this general impression by means of accurate figures.

"In the first place, if the dimensions of the central calm are considered, the only complete information we have on this point is the report of the *Laisang*. It has already been inferred, from the duration of this calm and the velocity of translation of the cyclone, that the diameter of that kind of chimney, measured at the level of the water in the direction East-south-east to West-north-west, must have been slightly over 8 miles. The tracing of the isobars leads us to think that this centre possessed an elliptic shape, somewhat elongated, with its greater axis directed almost exactly East to West, whilst the trajectory ran West by North. This inference is based upon the following considerations. We have seen that, unless the position of the *Laisang* at the time of the storm, were modified in a rather unjustifiable manner, that ship must have been somewhat to the north of the greater diameter of the central calm. On the other hand, the winds met with in the immediate vicinity of the calm must be perceptibly tangent to the isobar which limits that space. Now the calm on board the *Laisang* had been preceded by a storm from North, and it was followed by a hurricane of South by West. Let the reader draw a diagram and he will see himself that any inclination of the axis, different from that which we have just pointed out, would have brought on other winds than those which were observed, and which lasted more than a quarter of an hour intermixed with squalls from South-south-east, to be replaced gradually by winds from South, which ended by settling to South-south-east. The ellipse must at all events have had a very small eccentricity, but phenomena of this kind cannot be measured with a greater precision. A perfectly circular nucleus being admitted, with rather divergent winds at the limit of the calm, winds of South by West could be accounted for at the exit; but in the same hypotheses, the entrance into that same space could not have taken place with Northerly winds.

"At the time of coming near the coast, the centre had begun to fill up, for the barometer hardly sank under 710 mm. on board the *Chiyuen*, which experienced the calm. On the other hand, the *Descartes*, which was at only 20 miles south of the trajectory, had a minimum as high as 718 mm. while at sea in the previous evening, at the same distance, the barometer had fallen to 700 mm. It is equally beyond a doubt that the centre had contracted; for, unless ascribing to it an unlikely bend between the two said ships, the true

central point must not have passed very far from the *Chiyuen*, upon which yet there were hardly three minutes of calm.

"Once landed, the depression filled up rapidly, and we have already seen that the *Chasseloup-Laubat*, though at less than 20 miles from the centre, on the evening of the 4th, only experienced a minimum of 739 mm. Much about the same pressure was registered the day before at the Turnabout lighthouse, when the centre was yet distant by about 170 miles in the north-east.

"At the new lighthouse of the Hieh-shan islands, on Pei-yu-shan, 32 miles to the north-north-east of the Tai-chau anchorage, and about 128 miles north of the trajectory of the centre, the sea was the heaviest recorded. 'The centre of the light is 345 feet above high water; however the spray went right over the top of the tower, while the islets near, which are about 80 feet high, were entirely covered.'

"It is impossible, and it would be tiresome, to follow the disasters caused by the passage of the phenomenon along the Yang-tse-kiang. 'At Kiang-yng some people are said to have lost their lives, but it is reported that, some 20 miles farther down the river, the loss of life numbers 500. The oldest people here do not remember that the river ever rose to such a height before.' And so it was almost everywhere, at Wu-hu, Ngan-k'ing, Kiu-kiang, Hankau, and upon the lakes where, according to Chinese reports, corpses numbered thousands.

"*Variations of the Typhoon in shape and depth.*—The typhoon of August 3 is a striking instance of the modifications which a violent storm may undergo in the various phases of its existence. What it was in the first stage of its career, when taking shape or, when, already well framed, it darted towards the barrier of islands strewed between Formosa and Japan, we have now no means of saying. To the north of Formosa, over those immense waste spaces where the cyclone could freely grow and spread itself, it appears in the shape of a mighty atmospheric depression, with level lines almost circular, surrounding an elliptical space of calm, stretching its greater axis from west to east, whilst it propagates itself in a body in the direction of west by north.

"The existence of a centripetal component of the winds circulating within that immense disturbed space has been too well established over and over again to need being discussed here. We will only, as an instance, give the acute angle between the radius drawn from the observer to the centre and the direction of the breeze, in various azimuths and at various distances, on the 2nd about midnight, at which hour the centre was passing to the north of Keelung.

AUGUST 2, MIDNIGHT.

Bearing of the Centre	S.	S.S.E.	E.	E.N.E.	N.N.E.	N.	N.W.	W.	S.S.W.
Distance (miles)	112·7	84·0	86·3	110·3	96·0	93·5	165·4	60·0	208·6
Angle of the wind with the bearing	70°	58°	48°	45°	42°	6°	43°	80°	58°

"On the whole, it then appears that, within the really intense part of the perturbation, an observer, with his back to the breeze, had the centre at 10 points on his left (port) if he was on the north of the centre, at 11 points, if he was on the south, at 11·5 points on the west and forward, and lastly 9 points on the east and behind;—all this in open sea, far from local perturbations.

"As soon as the phenomenon drew near the coast, it underwent a rapid modification so as to make it unrecognisable. From the first the centre filled up rapidly, so that the minimum, which had attained the depth of 686 mm. in the offing, had risen to 710 mm. in the proximity of land, and reached 739 mm. one day later, on the banks of the Yang-tse-kiang. Another equally striking feature was the sudden suppression of the appendix in the shape of a chimney, which seems to characterise the centres of true typhoons.

"At the centre, a chimney or a sheath inclosing the calm comes to settle on the point of the cone, of greater or lesser width and depth, according to the degree of violence of the phenomenon. Such was the curve of the *Laisang;* such was also the elegant curve of the *Algerine*, which reproduced the other in miniature, though the result was in fact equally violent, as the energy of the typhoon had concentrated into a narrow space.

"On reaching China, the appendix of the typhoon of August 3 became suppressed, and the barograms, even nearest to the centre, as on board the *Lion*, the *Tung-chow*, the *Bengali*, and even the *Chasseloup-Laubat*, in lieu of the typical funnel, show now nothing but wide-mouthed basins or cups with gently sloping slides: the violent effects of the centre are then suppressed."

Meteorological Congress, Mexico, 1900.—We have received a volume entitled *Actos, Resoluciones y Memorias del Primer Congreso Meteorologico Nacional*, Mexico, 1901. The full title of this publication may be translated—Acts, Memoirs, and Decisions of the First National Meteorological Congress initiated by the "Antonio Alzate" Society and held in the City of Mexico on November 1, 2, and 3, 1900.

This publication marks an epoch in the meteorological literature of the Western hemisphere, as it is the first record of a Meteorological Congress held in Mexico.

The memoirs form a volume of 272 pages with several illustrations, one of which represents the principal members of the Congress (including a lady) assembled round a table.

It is highly satisfactory to find that Mexico under its present enlightened rulers is advancing so rapidly in the path of scientific investigation, as to support a Society like that named after Antonio Alzate and which has flourished for many years in Mexico, and under whose auspices the 1900 Congress was assembled. The deliberations of this Congress evince the keen scientific interest which the subject of meteorology has awakened in Mexico, and the Congress was opened under the superintendence of the Ministro de Fomento, an official who has no exact counterpart in our Government, and who may perhaps be best described as the "Minister of Education and Agriculture." The opening address to the Congress was, however, delivered by Señor Ordoñez, the president of the Antonio Alzate Society, and among other important things he said: "Meteorology, gentlemen, is with us a science which we are only beginning to apply in a practical manner, and one of the first things to remark is that each observatory in the country enjoys the most deplorable independence as to its methods of observation, a state of things which will never conduce to perfection nor enable us to carry out in practice the application of the results so carefully collected by the observers." He welcomed the various members who were present, and expressed the hope that each one, on returning to the quietude of his observatory, would remember that from this time he had a new mission to fulfil in pursuing an active propaganda amongst individuals and governing bodies with the object of creating more observing-stations; and that each member ought to recollect that his observations did not belong solely to himself, but were the property of the community, and were the organised efforts of modest workers who for a long time had pursued a grand ideal of transcendent importance, that of the successful prevision of the weather.

On the first day of the Congress the following papers were presented. Prof. R. Aguilar—"Historical Review of Meteorological Congresses and their Results." This was a concise account of the doings of the various European Congresses and Committee Meetings of Göttingen 1838, Cambridge 1845, Brussels 1853, Leipsic and Bordeaux 1872, Vienna 1873, Utrecht 1874, London 1876, Utrecht again 1878, Rome 1879, Berne 1880, Copenhagen 1882, Paris 1885,

Zurich 1888, Paris again 1889, Munich 1891, Chicago 1893, Upsala 1894, and again of Paris in 1896 and 1900.

Sr. Joachim de Mendizabal—"Modifications of various Meteorological Instruments." In this memoir the author sketched out a series of excellent rules for observing, recommending among other things the maximum and minimum thermometers of Negretti and Zambra, the adoption of Greenwich time, the use of the sling thermometer, the thermometers of Tonnelot, and the adoption of the form of publications used by the Roumanian Institute.

Rev. J. M. Arreola—"A new Evaporimeter." This was a suggestion for registering evaporation by means of a globular porous earthen pot, kept full of water by means of an elastic tube which led from a closed vessel or cistern placed on the pan of a spring balance, the scale of which was adjusted to register the weight of water evaporated in any given time. The cistern and the balance were to be within some building or cover, while the earthen globe was suspended in the air, but sheltered from the rain and sun.

Sr. G. B. de Puga—"Apparatus called the Meteorognosta." This was an arrangement of concentric cards so adjusted that by turning them in accordance with the readings of the various instruments an arrow was caused to point to the weather indicated by the combination of the various data.

Sr. M. E. Pastrana—"Description of a Nephoscope."

In the afternoon session of the first day were discussed the general questions proposed by the organisers of the Congress. After recommending the patterns of instruments to be used, which included the Robinson Anemometer, the Congress proceeded to discuss the matter of the site of observatories, and concluded to recommend that where possible they should be established at a distance from centres of population.

It was also decided to recommend sunshine observations by means of Arago's actinometer and earth temperature, by means of the "Systema Symonds" (Symons), thus doing our deceased President the honour he well deserves. It was also decided to place the rain-gauges at the uniform height of 1·50 metres above the soil or roof on which they happened to be placed, with the recommendation that when placed on a flat roof they should be in the middle of the same and not at the edge. Cloud altitude observations were to be instituted, and an order was to be issued that various observatories should take simultaneous cloud observations by means of theodolites and cameras.

On the second day of the Congress the following papers were read :—

Rev. S. Diaz—"Some Reforms in the Methods of Observation and simple Means for the scientific and popular Observations of the Air." In this paper the author proceeds to trace the various meteorological changes of pressure, temperature, and moisture solely to the winds, and he recommends strict uniformity in the published records.

Prof. L. G. Léon—"Application of Photography to Meteorology." This was a resumé of the history of photography as applied to the clouds and to the various self-registering instruments in use at observatories, and gave particulars of the numerous and interesting cloud photographs taken in Mexico during the year 1900, at the suggestion of the Mexican Society for the cultivation of Science. The paper is accompanied by three interesting cloud photographs, one of which shows a fine group of broken cumulus clouds piled up in picturesque confusion towards the zenith.

Prof. M. Moreno y Anda—"The Clouds and the Importance of observing them." This is a masterly review of the various systems of cloud nomenclature, and concludes by a description of the trigonometrical methods of observing cloud altitudes. Our own Howard is credited with his full share in the initiation of a methodical nomenclature of clouds.

Miss R. Sanchez Suárez—"The Barometer and the prevision of Weather."

This was a historical essay on the barometer, and gave an interesting account of its invention and development, and concluded by an earnest advocacy of the importance of establishing daily and simultaneous observations throughout the territories of the Mexican Republic.

Sr. J. M. Romero—"On the Publication of Meteorological Results." After a particular description of the meteorological publications of the United States and other countries, the author appeals to the rulers of Mexico to establish without delay a service for the prognostication of weather, which he considers would be of national, agricultural, and commercial importance.

In the afternoon session of November 2, the following among other resolutions were passed—

That certain observatories should inaugurate a series of hourly observations.

That the relative humidity and the vapour tension be calculated by the general formula

$$f = f^1 - AH\,(t - t^1)$$

That the meteorological year shall commence on December 1.

That the cloud atlas of Hildebrandsson and Teisserenc de Bort be adopted.

That it is desirable to commence systematic observations of the periodic phenomena of vegetation and of the migrations of certain birds.

That agriculturists be instructed to send in formal reports of unusual or accidental phenomena, hail, frosts, electric discharges, falls of meteors, earthquakes, and volcanic disturbances.

Third day—morning session.

Sr. D. Alejandro Prieto—"On the establishment of Meteorological Stations in the State of Tamaulipas."

Prof. Mariano Leal—"On the Creation of a Network of observing Stations."

Sr. Daniel Olmedo—"Note on the tropical Cyclone of September 1900"

At this session it was decided to recommend the governors of the various Mexican States to establish observatories in their capitals, and to transmit their observations to the Central Observatory in the City of Mexico, and also to establish, if possible, a complete network of stations throughout the country.

At the final sitting on the afternoon of November 3, the form of publication of the observations was discussed, and it was decided that the monthly Report should be on the model of that approved by the Munich Congress.

It was also decided to add the registered dates of the first and last frosts in each year, and to establish simple-patterned seismographs at the various observatories, and to carry out high altitude observations by means of unmanned balloons, and finally that ozone observations should be undertaken by means of the "Montsouris" direct chemical process. It was decided to hold another congress in 1901.

The volume before us also contains a memoir by the Rev. J. M. Arreola "On a new Theory of volcanic Action," and another by Sr. J. J. Urrutia "On the Climate of the City of Puebla," giving a very complete summary of 22 years' observations, though the author regrets certain gaps and defects in the same. He says of the Puebla climate: "In summer the mornings and evenings are always agreeable, in winter the days are always mild. Notwithstanding the latitude and altitude, neither heat nor cold are excessive, no warming apparatus is necessary in the houses, and in the spring families come by thousands to avail themselves of its beautiful and salutary climate. In Puebla our public walks and gardens enjoy an eternal verdure . . . and there only in pictures can one contemplate those sad landscapes where the roofs and the tree trunks are shown enveloped in their white shrouds of snow."

English meteorologists will join in congratulating Mexico on the success of

its first Meteorological Congress, and will hope for the continuance and extension of what has been so happily inaugurated.

Cumulus Clouds formed by Smoke.—During the field manœuvres and meteorological kite ascension of the Bayonne Kite Corps at their field station, November 28, 1901, a large column of smoke was observed to the northward. It was 11.30 a.m. when the smoke was first noticed, and while the members were speculating as to the location of the fire, the crest of the smoke column suddenly became capped with the white vapour of the cumulus cloud formation. Afterwards the smoke evidently rose higher than the white vapour between the observers and the new formed cloud, so that for a few moments it was invisible, only to reappear later. Finally the smoke dissipated, leaving the new formed cloud alone in the northern sky, and increasing in size. It was visible for nearly two hours before it finally disappeared from view.

The fire was slightly west of north from Bayonne and several miles distant. The minimum temperature of the day at Bergen Point was 18°, the maximum 27°. Sky absolutely clear at the time.—*Monthly Weather Review.*

RECENT PUBLICATIONS

Annuaire de la Société Météorologique de France. June—December 1901.

The chief articles are: "Les progrès de la météorologie en France dans la seconde moietié du xix^e. siècle": par G. Lemoine (11 pp.). This was the Presidential Address read before the Society on January 8, 1901.—"Le Nuage et son rôle dans la formation de la pluie": par C. Ritter (54 pp.). This paper is illustrated by numerous rough sketches of rain-producing clouds.—"Résumé des observations centralisées par le Service Hydrométrique du Bassin de la Seine, pendant l'année 1899": par M. Maillet (26 pp.).—"Contribution à l'étude de la variation diurne de la vitesse du vent": par P. Cœurdevache (2 pp.).—"Pluie mensuelle à Vendôme pendant la dernier moietié du xix^e. siècle": par E. Renou (3 pp.). The average monthly rainfall for the 50 years was as follows:—

January .	1·75	May . .	2·13	September .	1·91
February .	1·36	June . .	2·30	October . .	2·39
March . .	1·65	July . .	1·99	November .	1·99
April . .	1·73	August .	1·83	December .	1·87

The average total for the year is 22·90 ins.—"Sur la prévision des crues à Pommeuse et à Coulommiers à l'aide des hauteurs de pluie": par E. Maillet (19 pp.).—"Résumé d'un manuscrit de Bertrand sur l'état du ciel à Paris de 1698 à 1716": par E. Renou (3 pp.).

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-naturwissenschaftliche Klasse. 73. Band. Wien, 1901. 4to. 463 pp.

This volume commemorates the Jubilee of the Central Anstalt für Meteorologie und Erdmagnetismus. It commences with a historical review of the institution, by Dr. Pernter. The earliest observations go back to 1763, but the actual central institution owes its origin to a decree of the Emperor Franz Joseph of July 23, 1857. The first Director was Kreil, and he continued in office for 11 years. During his term of office the financial difficulties of the young office were most serious, the staff consisting of only two or three persons. The earliest office was in the Favoriten Strasse in Vienna; and it was not until 1869 that Jelinek, Kreil's successor, was able to secure the site of the present Institution, the

Hohe Warte, at Ober Döbling, a suburb on the north-west of Vienna. Jelinek held the position of Director for 14 years, 1862-1876. The most important feature of his rule was the issue of the *Meteorologische Zeitschrift* on May 1, 1866. The names of Jelinek and Hann appeared as Editors, and the new venture at once attained universal recognition as the highest authority in all branches of the science.

Jelinek died in 1876, and was succeeded by Hann, who held office for 20 years, resigning in 1897 in order to devote more time to his studies in the science. Dr. Pernter says that Hann's administration has been the most brilliant period of the Central Anstalt, and that he is the only meteorologist since Dove, who has been unanimously regarded by Meteorologists of all nations as being the very highest authority on all branches of the science.

The second paper is "The Meteorology of Vienna, 1852-1900" by Hofrath Hann, and this is most elaborately worked out. In each element we have a comparison between the older records from the city, and the more modern data from the Hohe Warte ; and as regards temperature there are also records from the old observatory of the University, which cover the period from 1775-1874, and thus for more than 20 years overlap those at the Central Station in the Favoriten Strasse, already mentioned. In this way Dr. Hann is able to obtain means for the period of 125 years. The other elements are necessarily treated in less detail, but the entire paper is a model of what a thorough discussion of the meteorology of a station should be.

The next paper is very brief. It is an account by Prof. Czermak of an apparatus he has constructed to reproduce the action of the Föhn in Alpine valleys.

The fourth paper is by Prof. Mazelle, "On the influence of the Bora on the daily range of some Meteorological Elements." In the 10 years 1886-95 there were 393 days of Bora. It occurs in every month, but principally in winter. In June there were only 4 days, and in July 8 days of this wind, in the whole 10 years. In each case the maximum wind velocity sets in earlier than in ordinary weather. The Bora reduces the temperature, but no distinct monthly march is evinced. It also delays the occurrence of the extremes in all seasons. The relative humidity is also reduced. The influence of the wind on cloud and rain is also discussed, and the paper closes with a series of tables, comparing Bora days with ordinary days.

The next paper is "On the Daily March of the Meteorological elements with a northerly Föhn," by Dr. Robert Klein, of Tragöss, Styria. At Tragöss there is a special Föhn observatory, and Dr. Klein was requested to draw up a report on the effects of the wind on the various elements. He gives the following summary of his results : 1. The march of all meteorological elements is materially modified by Föhn, in comparison with what is observed in ordinary weather. 2. All these disturbances may be explained by the intermission of the ordinary daily ascending current rising from the level ground. 3. Owing to the descent of a dry and relatively warm current from the mountain into the basin, Tragöss loses its basin climate, and there is a reversal of the seasons, the winter is warm, the summer cool, exactly as occurs on mountain tops.

The sixth paper is "On the Amount of Water contained in Clouds," by Dr. V. Conrad. The author shows that all the previous determinations of the size of drops of moisture in clouds have been defective, inasmuch as the aspirator is not able to draw in all the air about its opening, but much passes by. A glass bottle is emptied by an air-pump, and then a cock is opened so that a mass of cloud rushes in. The cock is closed, and the cloudy air drawn through chloride of calcium ; the experiments were carried out on the Sonnblick and at other mountain stations. The observation is confirmed that drops decrease with altitude.

The seventh paper is "On the Daily Range of Temperature in Austria," by J. Valentin. This is a most elaborate paper. The material is furnished by

Richard's thermographs at the following stations, O'Gyalla in Hungary, Munich, and Milan. These three are taken as being on plain country, a condition not fulfilled in the whole of Austria. Then we have Bielitz, Bucheben, Cracow, Graz, Gries, near Botzen, Innsbrück, Klagenfurt, Kremsmünster, Lesina, Mostar, Pola, Prague, Salzburg, Trieste, Vienna, the Sonnblick, Obir, and Bjelašnica. The whole inquiry is carried through in the most careful way, with tables for sunshine and for the obtaining of true daily means, from all the various combinations of hours, which have ever been suggested.

The eighth paper is "On the Daily Range of Temperature at Vienna for all days, as well as for clear and overcast ones," by S. Kostlivy. This is a very carefully worked-out paper, showing clearly the effect of the presence or absence of sunshine on the daily march of temperature.

The ninth paper is "On Hair Hygrometers," by J. Pircher. This is a careful investigation into the theory of different hair hygrometers, and as a result it is stated that Hair Hygrometers, if observed for a long period, give results which may be 5 per cent out in relative humidity. The two instruments especially investigated were Koppe's and Lambrecht's.

The tenth paper is "On the Polarisation of Light in troubled Media," by Dr. J. M. Pernter. This is a discussion of Lord Rayleigh's theory, which is very generally confirmed.

The eleventh paper is "On the Effective Work of a Distribution of Pressure and on the Maintenance of Differences of Pressure," by Dr. Max Margules. This is a purely mathematical discussion of the mechanics of the atmosphere.

The last paper is on "The Isotherms of Austria," by W. Trabert. This is the first time that any comprehensive study of the temperature has been undertaken, and isothermal maps for January, April, July, and October are given. The investigation is very thorough, and will well repay study.

Hints to Travellers, Scientific and General. Edited for the Council of the Royal Geographical Society by JOHN COLES, F.R.G.S. Eighth Edition. Vol. I. x. + 436 pp. Vol. II. vii. + 266 pp. 8vo. London, 1901.

This useful work has in the present enlarged edition been published in two volumes. Vol. I. is devoted to "Surveying and Practical Astronomy;" Vol. II. deals with "Meteorology, Photography, Geology, Natural History, Anthropology, Industry and Commerce, Medical Hints, etc."

The chapter on "Meteorology and Climatology" which has been entirely rewritten by Dr. H. R. Mill, extends to 51 pages with 5 plates. Of the many ways in which a traveller may add to the knowledge of atmospheric conditions, five are specially mentioned, viz.: 1. A record of the weather, observed day by day, with regard both to non-instrumental observations and the readings of instruments. 2. Observations for forecasting the weather and obtaining warning of storms. 3. Observations with a view to determining the character of the local climate. 4. Special meteorological researches. 5. The collection of existing meteorological records.

Indian Meteorological Memoirs: being Occasional Discussions and Compilations of Meteorological Data relating to India and the Neighbouring Countries. Published under the direction of JOHN ELIOT, F.R.S., C.I.E., Meteorological Reporter. Vol. XII. Part II. 4to. Calcutta, 1902. 31-315 pp.

The present memoir is devoted to a discussion of the data contained in the memoirs of the hourly observations at 29 stations in India, published in the

India Meteorological Memoirs, vols. v., ix., and x., chiefly with the object of investigating the relations of the diurnal variations of the air pressure to the diurnal changes of other elements of meteorological observation.

There is no doubt, from the results of recent investigations, that the diurnal oscillation of air pressure is due in part to general meteorological actions, common to the whole atmosphere, and in part to localised actions, the intensity of which varies very considerably at different stations. The chief object of the present memoir is to endeavour to separate these local effects and actions from the general effects and actions, and to determine, so far as is at present possible, the causes to which they are due. The data are examined and discussed in the following order: Solar radiation, Terrestrial radiation, Ground temperature, Temperature of the air, Aqueous vapour pressure, Cloud, Air movement, and Air pressure.

An examination of the Solar radiation data shows that they are more or less unsatisfactory, and are not inter-comparable, and so Mr. Eliot has not considered it necessary to discuss them.

With regard to Terrestrial radiation the data indicate that the grass radiation residuals decrease in amount with increase of cloud, and of aqueous vapour pressure.

The amount of the Solar radiation absorbed during its passage through the earth's atmosphere chiefly depends upon (1) the thickness of the air column traversed by the solar rays, and hence inversely upon the altitude of the sun; (2) the humidity of the atmosphere; (3) the amount of dust; and (4) the amount, density, and thickness of the clouds.

From an analysis of the changes of aqueous vapour pressure during the day in India we learn that:—

1. Diffusion diminishes the aqueous vapour pressure in the lowest strata by amounts which are greatest in the day hours when diffusion is slightly more rapid than in the night hours. This action gives rise to a variation of aqueous vapour pressure of 24 hours' period, the minimum about 2 p.m. and the maximum during the night hours.

2. Evaporation produces increase of vapour in the lowest stratum, greatest in the day hours when evaporation is most rapid. The rate of evaporation depends upon a variety of actions. It varies (*a*) inversely as the relative humidity of the air; (*b*) directly as the rate of the air movement over the water or other surface at which evaporation is occurring; (*c*) directly as the intensity of the Solar radiation, and hence inversely as the amount of cloud, dust, etc., present in the air.

These are all recurring actions of 24 hour period, the maximum intensity of which is about 2 p.m. Evaporation will hence give an oscillatory variation of aqueous vapour pressure of 24 hour period, the maximum of which will be about 2 or 3 p.m., and the minimum in the early morning.

3. Connective movements with the associated lower horizontal air movements give rise to a day oscillation varying very considerably in period and amplitude. They cause a decrease of vapour pressure, increasing in amount from 9 or 10 a.m. to 3 or 4 p.m., followed by an increase terminating about 7 p.m. The diurnal period of this action in India is on the average of the year about 10 hours. The amplitude varies very greatly with the season, and is a maximum in the Peninsula in March or April, and in the interior of Northern India in May.

4. Land and sea breezes give rise to the largest variations of aqueous vapour pressure. During the prevalence of the land breeze the amount of aqueous vapour is reduced below the mean of the day, the reduction being usually greatest shortly before the transition from the land to the sea breezes. Similarly during the prevalence of the sea breeze the aqueous vapour pressure rises above the mean, reaching its maximum at the coast stations from 2 p.m. to

4 p.m. when they are strongest. The variation in the aqueous vapour pressure due to this action is hence of 24 hour period, the maximum and the minimum occurring at different hours, depending upon the distances of the stations affected from the *sea*.

5. The up and down movements between the mountains of Northern India and adjacent plains give rise to large and irregular changes which probably contribute to reduce the aqueous vapour pressure on the mean in the day hours. This movement is alternating, consisting of a down movement from the hills to the plains in the night hours, and up movement from the plains to the hills in the day hours. There is an alternating inverse movement in the upper strata. The effect of the down movement in the night hours may tend to decrease the aqueous vapour slightly, at and near the foot of the hills, whilst that of the upper movement in the day hours may tend to give considerable irregularity.

Mr. Eliot gives the following summary of the more important results respecting the diurnal oscillation of the barometer:

(1) The early morning minimum occurs earliest in the day in May or June and latest in December or January. The range of variation is large, amounting to 1 hour 22 minutes in the monthly means for Extra-Tropical India, and 31 minutes for Tropical India. It occurs, on the average of the year, only 2 minutes earlier in Extra-Tropical than in Tropical India.

(2) The morning maximum is earliest in the day in June and latest in February, and hence at practically the same periods of the year as the corresponding phase of the early morning minimum. The annual range of variation is only 30 minutes for Extra-Tropical India, and 24 minutes for Tropical India.

(3) The afternoon minimum occurs earliest in the day in November or December, and latest in May or June. The annual variation in Extra-Tropical India is 1 hour 12 minutes, and in Tropical India 47 minutes.

(4) The evening maximum is earliest in November to January, and latest in May or June. The annual range of variation of its mean epoch for Extra-Tropical India and Tropical India is 38 minutes.

(5) The epochs of the maximum phases are much less variable than those of the minimum phases, the annual range of variation of the former in Extra-Tropical India being little more than a third of that of the latter.

(6) The variations of the morning phases are inverse, or opposite to those of the afternoon or evening phases—*i.e.* the epochs of the former are accelerated when the latter are retarded.

(7) The critical epochs of these phases occur about the time of longest and shortest days, and are evidently related to the period or duration of sunshine, as early morning phases accompany late afternoon and evening phases (the amounts of acceleration and retardation being nearly equal).

(8) The annual range of variation in the epochs of the minima phases is considerably greater than that of the maxima epochs. The range is considerably greater for the minima in Extra-Tropical India than in Tropical India, whereas that of the maxima is practically identical in amount in both areas.

(9) There are a number of important local peculiarities in the occurrence of the maxima and minima phases of the diurnal oscillation of pressure, of which the most important are given in the following five paragraphs. (*a*) The epochs generally occur earlier at coast stations than at neighbouring stations in the interior. (*b*) Position in mountain valleys accelerates the epochs of the morning maximum and the afternoon minimum and evening maximum. (*c*) The morning epochs are retarded, and the afternoon epochs accelerated at stations on mountain crests. (*d*) All the epochs are accelerated at the stations of Belgaum, Poona, and Deesa, situated within a short distance (the limit of the extension of the land

and sea breezes) from the west coast. (*e*) The epochs are generally retarded at Cuttack and Calcutta, situated about the same distance from the north coast of the Bay of Bengal as the stations in the preceding paragraph are from the west coast of the Arabian Sea.

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. December 1901—February 1902. 4to.

The principal articles are :—"Kurzer Ueberblick über die Thatsachen und Theorien auf dem Gebiete der atmosphärischen Polarisation": von Dr. Chr. Jensen (14 pp.). This is a lecture delivered at Hamburg before the German Naturforschen Versammlung. It goes at some length into the history of the subject, and closes with the following statement which is of interest :—"I would state that the Polariscope is an instrument not to be neglected in weather prognosis. My instrument has frequently, nay, very frequently, shown me approaching atmospheric disturbances at a time when mere optical observations could not detect the least trace of them. Within an hour or two after the instrument gave indications, the sky, which had been quite clear, got completely overcast. It seems possible from the displacement of the plane of polarisation to draw conclusions on the presence of a cloud bank below the horizon, and it is also possible, by means of the polariscope in fog, to ascertain if the sky above the fog is clear or not."

"Hat das Schiessen mit Geschützen Einfluss auf Gewitter und Hagelbildung?" von Dr. G. Lachmann (8 pp.). The author obtained leave to collect data at 12 artillery stations in North Germany. As the result of three years' observation, the author comes to the conclusion that the firing produced a reduction in the number of thunderstorms, but that no diminution was traceable in the number of hailstorms.

"Ueber Emission und Absorption der Wärme und deren Bedeutung für die Temperatur der Erdoberfläche": von Dr. Nils Ekholm (26 pp.). This is the first portion of a long paper in which Dr. Ekholm discusses and replies to Prof. Arrhenius's views as to the absorption produced by carbonic acid in the atmosphere.

There is also a paper by Dr. Hergesell on the publication of the International Committee on balloons, and a paper illustrated by Herr A. Sieberg showing a very remarkable formation of a whirlwind above a cumulus cloud.

"Ueber die Darstellung des jährlichen Ganges der Verdünstung": von G. Schwalbe (11 pp.). This is a paper the idea of which was suggested by Dr. Köppen. The author recognises the non-existence of any trustworthy atmometer, but holds that the printed results from good observations are comparable *inter se*. He comes to the following two conclusions :—1. The difference between the dry and wet bulb readings is a relative measure of the evaporation. At stations where the latter has a high value the difference is also great and *vice versâ*; and 2. The yearly range of the difference between the bulbs is related to the declination of the sun.

"Die Sonnenthätigkeit, 1833-1900": von W. J. S. Lockyer (13 pp.). This is a translation of the paper in the *Proceedings of the Royal Society.*

Proceedings of the Royal Society. Vol. LXIX. 8vo. 1901.

Contains :—"On the Seasonal Variations of Atmospheric Temperature in the British Isles and its Relation to Wind-direction, with a Note on the Effect of Sea Temperature on the Seasonal Variation of Air Temperature": by W. N.

Shaw, F.R.S., and R. W. Cohen (25 pp.). This paper is mainly concerned with the analysis of the seasonal variation of temperature of the British Islands into a series of simple harmonic curves. The authors give the following summary :—

The harmonic analysis of the curve of mean atmospheric temperature at stations in the British Isles shows that there is, compounded with the primary solar variation, a secondary half-yearly meteorological variation. The effect of this variation is to moderate and lengthen the winter, and to intensify and shorten the summer. The second-order curve which represents it has maxima which oscillate, in different years, over the first ten days of February and August respectively, and minima which oscillate over the first ten days of May and November.

With some exceptions, the effect is generally apparent in a single year's observations, and, owing to its varying position, its curve appears to have a larger amplitude in the analysis of the temperature curve of a single year than in that of the mean curve of a number of years. It is independent of the relative frequency of occurrence of cyclonic and anticyclonic weather, and of the relative temperature of the air during the prevalence of these different types of weather. It is partly due to a periodic variation in the relative frequency of occurrence of the "cold," "warm," and "temperate" winds, but is to some extent apparent during the prevalence of winds from all quarters.

It is not found, with maxima at the same epoch, in purely continental stations, such as Vienna and Agra.

A similar effect is found in the temperature variation of the sea-water at stations surrounding these Islands, and the atmospheric effect is probably connected with this.

A similar second-order periodic effect is also found in the variation in the magnitude of the barometric gradient between London and Valencia and London and Aberdeen. It is probable that this periodic variation in pressure plays some part in causing the similar variation in temperature.

Report of the Meteorological Council for the Year ending March 31, 1901, *to the President and Council of the Royal Society.* 8vo. London, 1901. 162 pp. and 3 plates.

A detailed account is given of the constitution of the Council, and of the steps taken to make up the statutory number of members of the Association, which was incorporated under the Companies Act in 1891, with the name of the "Meteorological Council."

The present Report gives more details as to stations etc., than previous ones. A new and interesting Appendix has been added, giving particulars of some conspicuous meteorological occurrences in 1900, such as gales, heavy rains, snowstorms, thunderstorms, droughts, and temperature.

Symons's Meteorological Magazine. Edited by HUGH ROBERT MILL, D.Sc., LL.D. October 1901—March 1902. 8vo.

The principal articles are: "Meteorology at the British Association" (11 pp.). This gives an account of the "Meteorological Breakfast" and an abstract of the papers read at the Glasgow Meeting in September last—"New Highland Meteorological Station," by R. C. Mossman (2 pp.). This station is at Achariach, in Glen Nevis, a remarkably steep and narrow valley 4½ miles south-east of

Fort William and 2½ miles south-west of the Ben Nevis Observatory. Rain fell on 29 days in October, and Mr. Mossman says that the following verse proving the influence of the Moon on rainfall, though originally penned for an equatorial station, may be adapted to this valley by merely altering the name :—

Now the weather depends on the Moon as a rule,
And I've found that the saying is true.
In Glen Nevis it rains when the Moon's at the "full,"
And it rains when the Moon's at the "new."
When the Moon's at the "quarter," then down comes the rain ;
At the "half" it's no better, I ween ;
When the Moon's at "three-quarters" it's at it again,
And it rains besides mostly between.

"Day Darkness in the City" : by J. E. Clark (3 pp.).—"Dust Showers in the south-west of England" (4 pp.), (see p. 68).—"The High Pressure of January 1902" (2 pp.). The highest observed reading of the barometer was 31·11 ins. at Aberdeen at 10 p.m. on the 31st.—"The Cold February of 1902" (4 pp.).

The Climates and Baths of Great Britain. Being the Report of a COMMITTEE OF THE ROYAL MEDICAL AND CHIRURGICAL SOCIETY OF LONDON. Vol. II. 8vo. xvi. + 628 pp. 7 maps. London: Macmillan & Co., 1902. 12s. 6d.

This volume which completes the work undertaken by the Committee in 1889, contains reports on the climates of the following districts, viz. 1. London and Middlesex, by Dr. W. Ewart: 2. The East Coast, by Dr. W. Murrell ; 3 The Midland Counties, by Dr. P. Horton-Smith ; 4. Lancashire, by Dr. R. Maguire ; 5. The Lake District, by Dr. H. L. Brooksbank ; 6. Northumberland, Durham, and Yorkshire, by Dr. W. S. Lazarus-Barlow ; 7. North Wales, by Dr. D. J. Leach ; 8. South Wales, by Dr. C. Theodore Williams ; and 9, Ireland, by Sir J. W. Moore, M.D.

It is only necessary to add that Dr. C. Theodore Williams was the Chairman, and Dr. P. Horton-Smith, the Secretary of the Committee, to show that the whole of the work has been thoroughly handled, and is of a high-class character.

It is gratifying to find that the data published in the *Meteorological Record* have been extensively used in the preparation of this work.

The information contained in this volume is extremely interesting and valuable. The following outline for the climatological reports will indicate the lines on which that part of the subject has been dealt with, viz. 1. Definition of District. 2. General Physical characters of District ; Protection from Winds ; Exposure, etc. 3. Brief Notice of Geological Formations, and soil, with special reference to dryness and humidity ; Configuration of surface, in relation to natural drainage ; Elevations ; Protection from wind, rain, and fog. 4. Trees, as affording protection, and modifying climate ; Vegetation, as evidence of character of climate. 5. Effects of Ocean Currents upon Climate of District. 6. General Description and Meteorology of District, with analysis of, and deductions from, the Tables ; Temperature of Air, Humidity, Prevailing Wind, Sunshine, Rainfall, Fog, etc. 7. Characters of the Climate in different seasons. 8. Detailed consideration of the climate characters, and special features of limited districts and resorts, with some mention of Drainage and Water Supply. 9. Prevalence of diseases. 10. Therapeutic effects of the climate, with indications as to their uses in particular Districts.

We can only give a few extracts, but we commend the whole volume to the notice of our readers.

The Relative Dryness of London.—Dr. Ewart says: "This is perhaps the single artificial modification incidental to the building of a town, of which it may be said that it is entirely satisfactory, particularly in a damp country such as this, and in the vicinity of a large river. The natural climate of London, as tested at adjoining stations otherwise similar, but not subject to the artificial influence in question, is relatively dry, and this is probably due to the permeable character of its soil in the gravel area. But with the exception of the large parks and open spaces, the town as a whole has undergone for years, and particularly during the last few years, a strong desiccating process. All surface water has been carefully drained away, and the many square miles covered by London thoroughfares have been made quite as impermeable by asphalte, or by the concrete foundation under the wood pavement, as are the roofed buildings which protect many more square miles of its surface. Whilst no water has gained access to the upper strata of the soil, the under surface water has been steadily drained away, leaving an increasing thickness of practically dry earth. The influence of this drying process, added to the smallness of the rainfall special to the Thames valley, has been conducive to the health and comfort of the inhabitants."

The North-East Coast.—Dr. Lazarus-Barlow says: "The classes of case for which these north-eastern parts are suitable, and here they are of the greatest value, are over-worked persons, both mentally and physically, who require a bracing treatment, particularly if they have lived in crowded cities or towns, and lead usually a sedentary life. To these must be added children, for whom the sands and sea-bathing are especially valuable."

"There is an unanimous opinion that no person should go to the north-east coast during the spring months owing to the prevalence of the East winds: nor is the opinion less unanimous that summer and early autumn are the most favourable seasons at which persons may hope to stay in Northumberland, Durham, and Yorkshire, particularly at the sea-coast portions of those counties, to the benefit of their health."

The volume is illustrated by several coloured maps, including maps of England and Wales, and also Ireland, showing elevations, rainfall map of the British Isles, etc.

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THE PREVALENCE OF GALES ON THE COASTS OF THE BRITISH ISLANDS DURING THE 30 YEARS 1871–1900.

By FREDERICK J. BRODIE, F.R.Met.Soc.

[Read March 19, 1902.]

EIGHTEEN years ago, in a paper entitled "The Equinoctial Gales—do they occur in the British Isles?"[1] the author, Dr. R. H. Scott, F.R.S., discussed the prevalence of storms on our coasts at various times in the year, as shown by records extending over the 14 years 1870 to 1883. The close of the century seemed a favourable time for re-opening an enquiry of considerable importance, not only to meteorologists, but to all persons who are concerned in matters so widely affecting our interests as a maritime nation. Striking out the year 1870 (the first year dealt with by Dr. Scott), there were at the end of 1900 a series of storm records extending over a period of 30 years. With so much additional material, it has therefore been possible to give wider scope to the discussion than was in any way practicable with the limited data at Dr. Scott's command.

The information upon which the former and the present paper are each based is that collected annually in the Meteorological Office for the purpose of testing the accuracy of the Storm Warnings issued to our coasts. The checking of these warnings was first instituted in 1870 in response to an enquiry in the House of Commons, and for the 7 years 1870-76 the full results were issued annually in the form of *Parliamentary Papers*. Since then the work has been conducted regularly, year by year, but the full results have not been published, a summary only being given in the annual *Reports of the Meteorological Council*. The material collected includes a statistical account not only of gales for which warnings have been issued, but also of gales missed, and in this way it constitutes, so far as I am aware, the most complete record of the kind

[1] *Quarterly Journal Royal Meteorological Society*, vol. x. p. 236.

in existence. For permission to make use of this very valuable material (and without it the present discussion could scarcely have been undertaken), I am indebted to the kindness of the Meteorological Council.

Prior to 1876 the record of gales comprised, firstly, extracts from the automatic records of the various anemometers in connection with the Meteorological Office; secondly, the data supplied by the Telegraphic Reporting Stations; and thirdly, those furnished by a number of voluntary observers. In 1876 these details were supplemented by information extracted from the logs of several Lighthouses and Lightships, the documents being kindly lent for the purpose by the authorities of the Trinity House, the Scottish Meteorological Society, the Board of Irish Lights, and the Mersey Docks and Harbour Board. After the year 1889 the information from the latter sources was largely increased, while the reports from voluntary observers were no longer used. Owing to these changes and additions there has been throughout the period a gradual improvement in the value of the information employed, but for the bulk of the time the stations of various kinds have been so well distributed that it has been quite impossible for a gale of any consequence to spring up on our coasts without a record of it appearing in the annual list.

The definition of a gale employed in the present discussion is somewhat wider than that adopted in the earlier enquiry. The author in that case decided to take no account of a gale unless the wind attained force 9 of the Beaufort Scale at more than two stations, or a velocity exceeding 50 miles an hour nominal was recorded by an anemometer for more than one hour. Inasmuch as the Meteorological Office has always considered a storm warning to be fully justified if followed by a gale blowing force 8, or with a velocity (nominal) of 40 miles an hour, I have felt justified in following the Office lead, and in adopting these as the minimum limits. I have, however, included in my list cases only in which such forces and velocities were general over at least a limited portion of the United Kingdom, and have rejected cases in which they were reported only in a few isolated places. In some instances a gale was experienced at a considerable number of places scattered over a wide area; these could scarcely be ignored, and they have consequently been classed as "sporadic" gales. A severe gale has been taken to mean one in which the wind blew with a force of at least 10 by the Beaufort Scale, or with a velocity (nominal) of at least 60 miles an hour. No notice whatever has been taken of purely local occurrences, such as whirlwinds or tornados.

In attempting to group the gales according to the extent or locality of coast affected, it became evident from the outset that, if the enquiry was to be kept within reasonable limits, it would be impossible to adopt any very minute classification. After much consideration it was finally decided to divide the United Kingdom into the four principal quadrants—North, West, South, and East. In a strict sense the Northern quadrant was taken to mean Scotland only; the Western quadrant Ireland and the neighbouring Seas and Channels; the Southern quadrant the English Channel; and the Eastern quadrant that portion of coast lying between the mouths of the Thames and the Tweed. A considerable amount of elasticity has, however, been allowed in the grouping. Many of the gales,

for instance, which visit Scotland extend also over the extreme northern parts of England and Ireland, and sometimes over a portion of the Irish Sea. In such a case the gale has been grouped as one in the North only. Similarly with the other quadrants. A gale in the West often extends along the West of Scotland, and sometimes touches also the mouth of the English Channel; this has been classified as a gale in the West only. A gale in the South, which was felt also in the South of Ireland, and sometimes even a little north of the Thames, is grouped as one in the South only. And lastly, a gale in the East which extended northwards, say as far as Aberdeen, and in some cases touched the South-east coast of England, has been set down as in the Eastern division only. With these divisions in view the classification finally adopted was as follows:—

A = General gales, or gales which were felt in at least three of the four quadrants.
B = Gales in the West and North only.
C = Gales in the West and South only.
D = Gales in the North and East only.
E = Gales in the East and South only.
F = Gales in the West only.
G = Gales in the North only.
H = Gales in the South only.
J = Gales in the East only.
K = Sporadic gales (the definition of these has been already given).
L = Local gales, *i.e.* gales felt at several stations, but in a portion only of one quadrant.

In cataloguing the storms of the 30 years the severe gales were indicated by the letters P and S. The letter P indicated that the gale was partially severe, *i.e.* severe in one quadrant only, or at less than half the stations; the letter S indicated that the gale was severe in more than one quadrant, or at more than half the stations.

General Results.

The general results of the enquiry are shown in Table I., giving for each of the 30 years the total number of gales, grouped in accordance with the foregoing classification, together with means for the entire period.

The table shows that there are in this country on an average 48·5 gales per year, of which 10·6 are severe or partially severe.

Of the total of nearly 49 gales:—

10·7, or 22 per cent, are General; and of these 2·3 are severe, and 3·4 partially severe.
8·3, or 17 per cent, are felt only in the West and North; and of these 0·2 only are severe, but 1·6 partially severe.
4·3, or 9 per cent, are felt only in the West and South; and of these 0·2 only are severe, and 0·7 partially severe.
0·6, or 1 per cent, are felt only in the North and East; and of these none are severe, and only 0·1 partially severe.
1·1, or 2 per cent, are felt only in the South and East; and of these only 0·2 are severe, and only 0·1 partially severe.
5·6, or 12 per cent, are felt only in the West; and of these none are severe, and only 0·3 partially severe.

6·7, or 14 per cent, are felt only in the North ; and of these 0·2 only are severe, but 0·6 partially severe.

2·5, or 5 per cent, are felt only in the South ; and of these 0·2 only are severe and 0·2 partially severe.

0·9, or 2 per cent, are felt only in the East ; and of these none are either severe or partially severe.

3·0, or 6 per cent, are Sporadic gales ; and of these 0·2 are either severe or partially severe.

4·7, or 10 per cent, are Local gales ; and of these 0·1 are either severe or partially severe.

The total number of gales in each year is further shown graphically in the diagram, Fig. 1, the continuous curve giving the number of gales of all kinds, and the dotted curve the number of severe or partially severe gales. In each case a horizontal line drawn through the curve shows the average number for the 30 years.

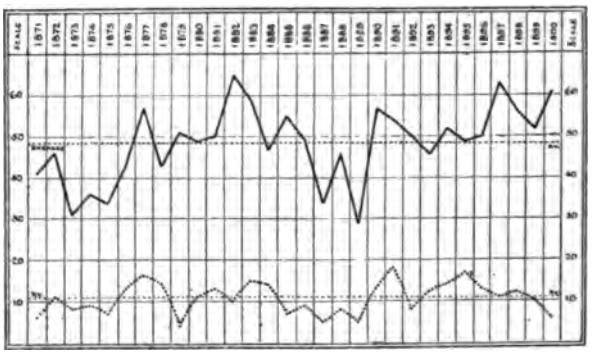


Fig. 1.—Total Number of Gales in each Year, 1871-1900.

It will be seen from the diagram that the maximum number of gales occurred in 1882, when there were as many as 65, or 34 per cent more than the average. The number of general and of severe gales in that year differed, however, but little from the normal, so that upon the whole it could scarcely be regarded as the worst year of the series. The latter distinction may be awarded more justly to the succeeding year 1883, for although the total number of gales was then smaller than in 1882, or indeed than in two or three other years, the number of general and of severe gales was in each case largely in excess of the normal. In 1883 there were no fewer than 28 general gales, as against an average of 11; and of these 3 were severe, and 10 partially severe. No other year of the series had anything like so large a number, the nearest approach to it being in 1877, in 1881, and in 1890, in each of which years there were 17 general gales, many of them of considerable severity. The largest number of severe or partially severe gales (18) occurred in 1891, but less than half of these were general, the remainder occurring on limited portions of our coasts. In two other years, 1877 and 1895, the number of severe gales was slightly larger than in 1883, but that does not seem to entitle the year 1883 to be regarded otherwise than as the

Years.	Gales of all kinds.		General Gales.			Gales experienced in																					Sporadic Gales.		Local Gales.	
						W. and N.			W. and S.			N. and E.			S. and E.			W. only.			N. only.			S. only.			E. only.				
	Total Number.	Severe or Partially Severe.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	No.	S.
1871	41	6	5	2	...	9	...	1	3	...	1	1	...	...	...	...	...	11	...	2	6	...	...	1	...	...	2	...	...	2	...	1	...
1872	46	11	11	3	3	7	...	1	9	1	2	1	...	...	...	...	...	3	...	...	4	...	...	3	1	...	2	...	...	2	...	4	...
1873	31	8	8	...	4	8	...	1	2	...	...	...	...	...	...	...	...	3	...	...	4	2	1	1	...	...	...	...	...	4	...	1	...
1874	36	9	9	5	2	7	...	1	3	...	...	...	...	...	...	...	...	6	1	...	7	...	...	...	...	...	...	...	...	...	...	4	...
1875	34	7	9	1	4	4	...	1	3	...	...	1	1	...	1	...	...	7	...	...	4	...	...	...	...	...	2	...	...	2	...	1	...
1876	43	13	12	2	6	10	...	3	5	...	...	1	...	...	3	1	...	1	...	...	4	...	1	1	...	...	1	...	...	2	...	3	...
1877	57	16	17	6	3	15	1	2	2	...	1	2	...	...	1	1	...	7	...	1	6	...	...	1	...	...	2	1	...	...	...	4	...
1878	43	14	11	3	4	10	1	2	3	...	...	...	...	...	1	...	...	2	...	...	1	...	...	4	...	1	3	...	...	5	3	3	...
1879	51	4	5	...	2	9	...	2	7	...	...	...	...	...	2	...	...	7	...	...	7	...	...	3	...	...	2	...	...	2	...	7	...
1880	49	11	9	3	2	10	...	2	3	...	...	...	...	...	3	...	...	5	...	...	11	...	4	2	...	...	...	...	...	1	...	5	...
1881	50	13	17	5	3	9	1	2	2	1	...	...	...	...	2	...	...	2	...	...	9	1	...	2	...	...	...	...	...	1	...	6	...
1882	65	10	11	...	2	9	1	1	9	...	3	...	...	...	4	2	...	8	...	...	11	...	1	5	...	...	...	...	...	4	...	4	...
1883	59	15	28	3	10	8	...	1	3	...	...	...	...	...	2	...	...	1	...	...	5	1	...	1	...	...	...	...	...	5	...	6	...
1884	47	14	9	3	3	8	...	3	5	1	1	...	...	...	...	...	...	3	...	...	9	...	2	4	...	...	1	...	...	5	1	3	...
1885	55	7	11	1	2	5	...	...	4	...	...	...	...	...	2	...	...	3	...	...	8	...	1	14	1	2	...	...	...	3	...	5	...
1886	49	9	11	2	4	4	...	1	12	...	1	...	...	...	...	...	...	6	...	...	5	...	...	5	1	...	...	...	...	5	...	1	...
1887	34	5	5	1	...	5	...	...	7	...	2	...	...	...	...	...	...	4	...	...	2	...	...	1	...	1	...	...	...	8	1	2	...
1888	46	8	13	...	5	6	1	1	3	...	...	1	...	1	2	...	...	5	...	...	5	...	...	4	...	...	...	...	...	6	...	1	...
1889	29	5	5	2	2	3	...	...	5	...	...	...	...	...	1	...	...	1	...	...	8	...	1	2	...	...	...	...	...	3	...	1	...
1890	57	13	17	4	5	8	...	1	4	...	1	1	...	...	1	...	...	6	...	1	12	...	...	...	...	...	1	...	...	3	...	4	1
1891	54	18	12	4	4	13	...	5	5	1	...	1	...	1	...	...	...	1	...	1	9	...	...	2	2	...	...	...	...	2	...	9	...
1892	50	8	9	...	2	8	...	2	3	...	1	1	...	...	1	...	...	7	...	...	8	...	2	2	...	1	...	...	...	3	...	8	...
1893	46	12	10	2	6	6	...	...	2	...	1	...	...	...	1	1	...	9	...	1	8	...	1	1	...	...	1	...	...	2	...	6	...
1894	52	14	11	4	3	16	...	6	3	1	...	1	...	...	...	...	...	10	...	...	3	...	...	1	...	...	1	...	...	2	...	4	...
1895	49	17	9	4	3	4	...	2	5	...	3	3	...	1	2	1	1	5	...	1	7	...	...	2	...	...	...	...	...	3	...	9	1
1896	50	13	9	3	3	7	...	1	4	...	2	1	...	...	...	...	...	8	...	1	6	...	...	5	1	2	1	...	...	4	...	5	...
1897	63	11	5	1	4	16	...	3	5	1	2	2	...	...	...	...	...	9	...	...	11	...	...	3	...	...	1	...	...	2	...	9	...
1898	56	12	10	...	6	7	...	1	1	...	...	...	...	...	2	...	...	10	...	2	9	1	2	1	...	...	2	...	...	4	...	10	...
1899	52	10	12	2	4	9	...	1	3	...	1	1	...	...	1	...	...	5	...	...	5	...	2	2	...	...	3	...	...	2	..	9	...
1900	61	6	12	3	2	9	...	...	4	...	...	...	...	...	1	...	1	13	...	...	7	...	...	3	...	...	2	...	...	4	...	6	...
Totals	1455	319	322	69	103	249	5	47	129	6	22	18	1	3	33	6	2	168	1	10	201	5	18	76	6	7	27	1	...	91	5	141	2
Means	48·5	10·6	10·7	2·3	3·4	8·3	0·2	1·6	4·3	0·2	0·7	0·6	...	0·1	1·1	0·2	0·1	5·6	...	0·3	6·7	0·2	0·6	2·5	0·2	0·2	0·9	...	...	3·0	0·2	4·7	0·1

stormiest one of the whole series. With respect to gales which occurred only on limited portions of our coasts, we see from Table I. that in the West the largest number occurred in 1900, in the North in 1890, in the South in 1885, and in the East in 1878 and 1899. In 1885 the number of gales affecting our South coasts only was nearly three times as great as in any other year of the series. Sporadic gales were most numerous in 1887, and local gales in 1898.

The quietest year of the 30 was 1889, when the total number of gales of all kinds was only 29, or nearly 40 per cent less than the average. The number of general and of severe gales in that year was in each case less than half the average, the former class being as rare as in any other year of the period. Next to 1889 the calmest year appears to have been 1873, with a total of 31 gales, and after that 1875 and 1887, each with a total of 34.

A period of 30 years is far too short to yield any reliable evidence as to the existence of periodicity in the matter of stormy weather. Assuming for a moment that the features shown in Fig. 1 are permanent and not merely accidental, there may perhaps be said to be some faint indication of a storm cycle recurring about every 15 to 17 years. In the upper curve of the diagram we find a decided excess in the number of gales in 1882 and 1883, and again between 1897 and 1900, with secondary maxima in 1877 and in 1890 and 1891. The periods of minimum gale frequency are even more clearly marked, a decided paucity being shown in the three years 1873-75, and again in the three years 1887-89. If there is any significance at all in these features we should now be entering upon a period of comparatively calm weather.

Monthly and Seasonal Prevalence of Gales.

The average number of gales of various kinds experienced in each month, and in each season of the year, is given in Table II., the monthly averages being also shown in Fig. 2. From an examination of Fig. 2 we see, without any surprise, that June and July are the quietest months, the average number of gales in the former month being rather smaller than in the latter. With the advance of August the tendency for stormy weather rapidly increases, the curve showing a brisk rise until October, and a somewhat less rapid rise towards the end of the year. The stormiest month of all is January, with an average of 7·4 gales, 2 of which are general, and 2 severe or partially severe. In February there is a great falling off in the number of gales, but in March the tendency for stormy weather increases in a somewhat remarkable way, the average number of gales in that month being 5·9, as against only 5·5 in February. After March the conditions rapidly improve, the curve of monthly values showing a brisk drop in April, and a more gradual fall to the summer minimum. The curve giving the monthly prevalence of severe or partially severe gales is very similar to the curve of gales of all kinds. Severe gales are most numerous in January, but the decline which takes place in February is arrested in March, the number in these two months being precisely similar. Between the months of April and August severe gales are rare, and in July they may be said to be non-existent. The stormiest month in the entire 30-year period was January 1890. The

TABLE II.—Mean Number of Gales experienced on the Coasts of the British Islands in each Month and in each Season of the Year for the 30 Years 1871-1900.

Months.	Gales of all kinds.		General Gales			Gales experienced in																											
						W. and N.			W. and S.			N. and E.			S. and E.			W. only.			N. only.			S. only.			E. only.			Sporadic Gales.		Local Gales.	
	Total Number.	Severe or Partially Severe.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	P.	No.	S.	No.	S.
January	7·4	2·2	2·1	0·4	0·8	1·4	...	0·5	0·6	...	0·1	0·1	...	...	0·1	...	...	0·9	...	0·1	1·1	...	0·2	0·1	...	...	...	...	...	0·3	0·1	0·6	...
February	5·5	1·2	1·1	0·3	0·3	0·9	...	0·2	0·4	...	...	...	...	...	0·1	...	...	0·6	...	0·1	0·8	...	0·1	0·2	...	...	0·1	...	...	0·3	...	0·8	...
March	5·9	1·2	1·1	0·1	0·5	0·9	...	0·2	0·5	...	0·1	0·1	...	...	0·2	...	...	0·6	...	...	1·2	0·1	...	0·3	...	...	0·1	...	...	0·4	0·1	0·5	...
April	2·7	0·3	0·3	0·1	0·1	0·4	...	...	0·2	...	...	0·1	...	...	0·1	...	...	0·4	...	...	0·4	...	...	0·2	...	...	...	...	...	0·2½	...	0·5	...
May	1·6	0·1	0·1	...	...	0·2	...	...	0·1	...	...	0·1	...	...	...	...	...	0·3	...	...	0·3	...	...	0·1	...	...	...	...	...	0·1	...	0·3	...
June	0·7	0·1	0·1	...	...	...	...	...	0·1	...	...	...	...	...	...	...	...	0·2	...	...	0·2	...	...	0·1	...	...	...	...	...	...	...	0·1	...
July	0·8	...	0·1	...	...	...	...	...	0·2	...	...	...	...	...	...	...	...	0·1	...	...	0·2	...	...	0·1	...	...	...	...	...	0·1	...	0·1	...
August	1·7	0·2	0·3	...	0·1	0·1	...	...	0·3	...	...	...	...	...	...	...	...	0·4	...	...	0·1	...	...	0·3	...	...	0·1	...	...	0·1	...	0·1	...
September	3·1	0·5	0·6	0·1	0·1	0·3	...	...	0·3	...	0·1	...	...	...	...	...	...	0·3	...	...	0·6	...	...	0·2	...	...	0·1	...	...	0·3	...	0·3	...
October	5·7	1·2	1·3	0·2	0·4	1·3	0·1	0·1	0·3	...	0·1	0·1	...	...	0·3	...	...	0·4	...	...	0·6	...	...	0·4	0·1	0·1	0·1	...	...	0·4	...	0·4	...
November	6·5	1·7	2·2	0·5	0·6	1·3	...	0·2	0·6	...	0·2	...	...	...	0·2	0·1	...	0·7	...	...	0·4	...	...	0·2	...	...	0·3	...	...	0·3	...	0·4	...
December	7·0	2·0	1·6	0·5	0·5	1·5	...	0·4	0·7	0·1	0·1	...	...	...	0·2	...	...	0·8	...	0·1	1·0	...	0·1	0·4	...	0·1	0·1	...	...	0·3	...	0·5	...
Spring	10·2	1·6	1·5	0·2	0·6	1·5	...	0·2	0·7	...	0·1	0·2	...	0·1	0·3	0·1	...	1·2	...	...	1·8	0·1	...	0·6	...	...	0·2	...	...	0·7	0·1	1·4	...
Summer	3·1	0·2	0·4	...	0·1	0·1	...	...	0·5	...	...	...	...	...	...	...	...	0·6	...	...	0·5	...	...	0·4	...	...	0·1	...	...	0·2	...	0·3	...
Autumn	15·3	3·3	4·1	0·9	1·2	3·0	0·1	0·3	1·3	...	0·3	0·2	...	...	0·4	0·1	...	1·3	...	...	1·5	...	0·1	0·8	0·1	0·1	0·5	...	...	1·1	...	1·1	...
Winter	19·7	5·4	4·6	1·2	1·6	3·6	...	1·0	1·8	1·0	0·3	0·2	...	...	0·4	...	0·1	2·4	...	0·2	2·8	0·1	0·4	0·7	0·1	0·1	0·2	...	...	1·0	0·1	1·8	...
Summer Half-year	10·6	1·1	1·4	0·2	0·3	1·0	...	0·1	1·1	...	0·1	0·2	...	...	0·1	...	...	1·6	...	0·1	1·7	...	0·1	0·9	...	0·1	0·2	...	...	0·8	...	1·5	...
Winter Half-year	37·6	9·6	9·3	2·1	3·3	7·1	0·2	1·5	3·2	0·2	0·6	0·5	...	0·1	1·0	0·2	0·1	4·0	...	0·3	4·9	0·2	0·5	1·7	0·2	0·2	0·6	...	...	2·2	0·1	3·1	...
Entire Year	48·5	10·6	10·7	2·3	3·4	8·3	0·2	1·6	4·3	0·2	0·7	0·6	...	0·1	1·1	0·2	0·1	5·6	...	0·3	6·7	0·2	0·6	2·5	0·2	0·2	0·9	...	...	3·0	0·2	4·7	0·1

Note.—The figures under the letters S denote in each case the mean number of *Severe* gales, and these under the letters P the mean number of *Partially Severe* gales.

total number of gales of all kinds in that month was, it is true, slightly smaller than in January 1894, in March 1897, or in the Novembers of 1882 and 1888. Of the 12 gales which occurred, however, in January 1890 no fewer than 7 were general, and of these 3 were severe and 3 partially severe. In addition to these, there was 1 partially severe gale in the West and North only, and 1 in the West and South, so that out of the total of 12 gales no fewer than 8 were either severe or partially so.

The seasonal results show that an on average there are considerably more than three times as many gales in the winter half of the year

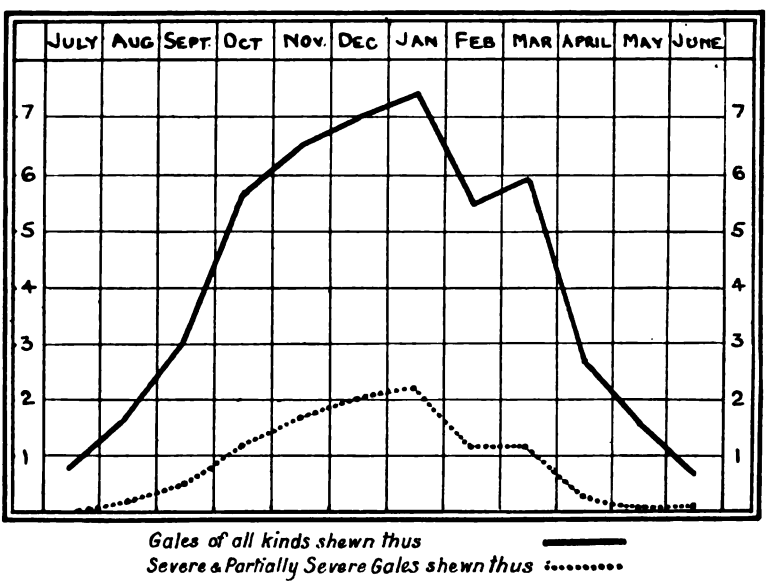


FIG. 2.—Mean Monthly Prevalence of Gales.

(October to March) as in the summer half (April to September), the actual numbers being 37·6 and 10·6. Looking at each of the four seasons individually, we see that there are on an average only 3 gales in the summer (June to August), but 10 in the spring (March to May), 15 in the autumn (September to November), and 20 in the winter (December to February). The mean of the severe and partially severe gales follows the same order. In the summer there are only 0·2, but in the spring there are 1·6, in the autumn 3·3, and in the winter 5·4. A complete record of the number of gales of all kinds experienced in each season of the 30-year period will be found in the diagram, Fig. 3. The date given for the winter is in each case the concluding date of the season, the winter represented under the year 1871 being that comprised within the 3 months commencing with December 1870, and so on. It will be seen from the diagram that the stormiest winter by far was that of 1893-94, when there were as many as 34 gales, as against an average of 20. Of the 34 gales 10 were general, and 12 were either severe or partially severe. The number of general gales was, however, slightly less than in the winter of 1882-83, and the number of severe gales was not quite so

large as in 1876-77. The quietest winters were those of 1877-78 and 1888-89, when there were only 13 gales of all kinds, and only 4 general gales. In the former case 2, and in the latter case 3, of the gales were severe or partially so, but in this respect the two winters in question were excelled by those of 1878-79, 1887-88, and 1890-91; in the winter of 1878-79 there was an entire absence of severe or partially severe gales. Having regard only to the total number of gales, the stormiest autumn of the 30-year period was that of 1882; the number of general autumn gales was, however, greatest in 1881, while the number of severe gales was greatest in 1891. The calmest autumn of the series was that of 1889, when there were only 8 gales

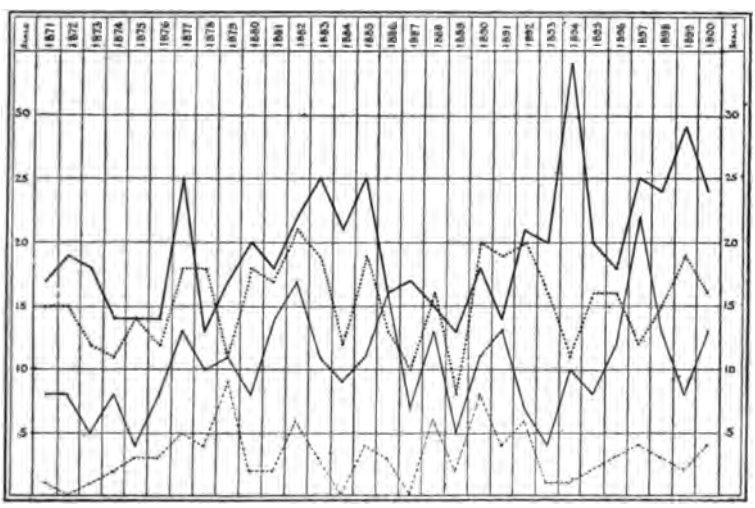


FIG. 3.—Total Number of Gales in each Season.

of all kinds (very little more than half the average), and only 1 partially severe gale. The most boisterous spring was that of 1897, the total number of gales of all kinds (22) being more than twice the average. Only 1 of these was, however, general, and only 2 severe or partially severe. In the springs of 1876 and 1878 the total number of gales was far smaller than in 1897, but in each case there were as many as 4 general gales, and 5 severe or partially severe ones. The quietest springs of the 30-year period were those of 1875 and 1893, each with a total of only 4 gales; in the former case none of them were severe, and in the latter case only 1 was partially so. Summer gales were most frequent in 1879, a season which, it may be remembered, was at the same time one of the coldest and wettest on record. In that year there were in all 9 gales, but of these 5 were felt only on our Western and Southern coasts. In the summers of 1872, 1884, and 1887 there were no gales of any consequence on any part of our coasts.

The Prevalence of Gales as shown by Five-day Means.

The prevalence of gales at various times in the year, as shown by 5 day means, is given in Figs. 4 and 5. The information in each diagram is of a similar character, but is somewhat differently arranged. In Fig. 4 curves are given for the entire year, commencing, for the sake of symmetry, with July. In Fig. 5 the year is divided into the summer and the winter halves. In each case a continuous curve shows the mean number of gales of all kinds, while a dotted curve shows the number of severe or partially

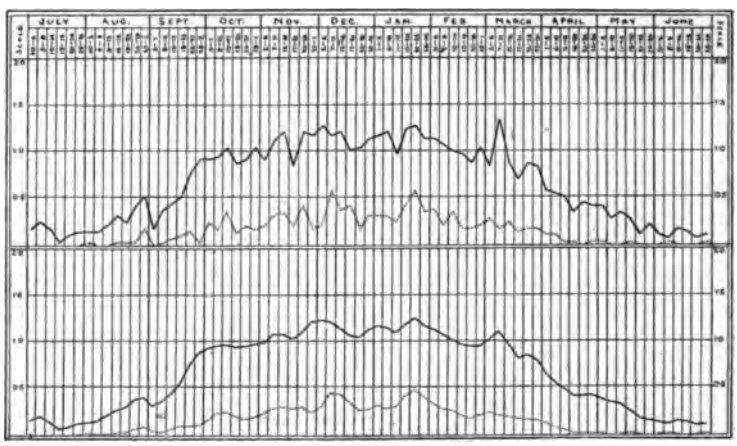


FIG. 4.—Average Prevalence of Gales, as shown by Five-day Means.

severe gales. In the lower part of Fig. 4 the curves are drawn from the original data, smoothed by the usual formula, according to which

$$B \text{ is equal to } \frac{A + 2B + C}{4}$$

Looking first of all at these smoothed curves, in which the broad features of gale prevalence are shown, we find that, after the middle of July, the tendency for stormy weather begins to increase slowly, but steadily, from the usual summer minimum. At the beginning of September there is a decided check in the rise, but after this the gale prevalence increases rapidly until the beginning of October. For about a month scarcely any change takes place, the end of October being very little more disturbed than the beginning. In November, however, gales become more probable, and from this time onward to about the middle of February we may look for stormy weather at any time. The maximum number of gales and also of severe gales, occurs in the 5-day period, January 21-25; but gales of all kinds are almost as numerous in the early part of December, while a decided maximum of severe gales (second only to that in January) occurs in the two 5-day periods, December 7-11 and 12-16. After the stormy time in January the weather tends to become rather more quiet, a gradual decrease in gale frequency being recorded throughout nearly the whole of February.

Quite at the close of that month, however, and in the early part of March, a remarkable revival of rough weather takes place; and on looking at the upper portion of Fig. 4, in which no smoothing process has been allowed, we see that in the 5-day period, March 7-11, the average number of gales of all kinds is greater than at any other time in the year. After this strange outburst the weather rapidly quiets down, and, with the exception of a small revival towards the end of March, the curve of gale frequency descends slowly, but rather unsteadily, to the summer minimum.

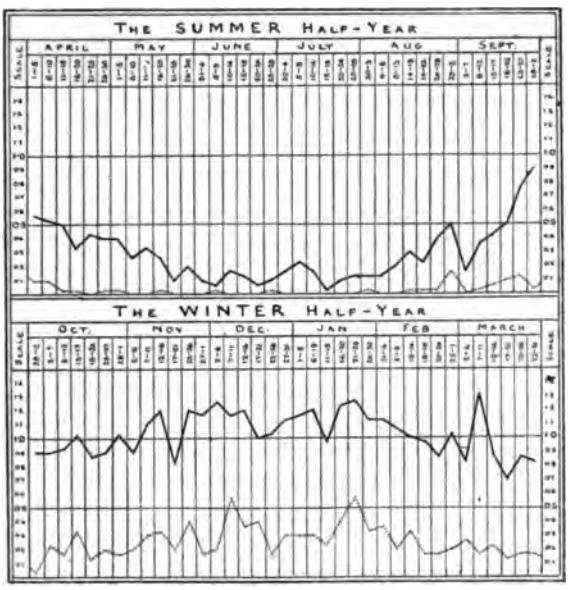


FIG. 5.—Average Prevalence of Gales in Summer and Winter.

One very peculiar feature shown by the curves (which seems to admit of no scientific explanation) is the striking tendency that exists for the weather to become calm just after the middle of some of the months. This is shown most clearly in the winter half of the year, as will be seen by the following statement giving the dates of the 5-day periods in which the monthly minimum of gale frequency occurs:—

In October it occurs	during the	5-day period	18-22
„ November	„	„	17-21
„ December	„	„	17-21
„ January	„	„	11-15
„ February	„	„	20-24
„ March	„	„	17-21

We thus see that in 4 out of the 6 months the minimum occurs at almost precisely the same time, and if we include April (when the minimum occurs in the period 16-20) we have 5 months out of 7 with a spell of comparatively quiet weather, occurring in each case when the middle of the month has turned. In January the minimum is registered

somewhat earlier, and in February somewhat later, than in the other months. The same tendency is observable, though less clearly, in the summer half-year. In April the occurrence of the minimum follows, as we have already seen, the general winter rule. In May it occurs in the period 21-25. In June there are two minima, the second occurring in the period 20-24. In July the minimum is noted between the 15th and 19th. In August and September the tendency for stormy weather is gradually increasing, but an examination of the curves shows that in the former month there is a decided check in the upward movement in the period 19-23, while in September there is a less decided check in the period 18-22.

The curves in the upper portion of Fig. 5 afford some guidance to the nervous voyager in selecting a fairly safe time for a summer cruise around our shores. At no time in the year can we promise him absolute freedom of risk from bad weather, but there are certain portions of the summer months that may be chosen with a fair amount of confidence, and others that should be avoided. The best times for a short trip would appear to be the earlier or the latter days of June, avoiding, if possible, the middle of the month. For a longer cruise the curve seems to recommend the latter half of July and the first week in August, the earlier half of July being decidedly risky. Towards the middle of August the weather tends to become more stormy, and for a short trip it would be wise to wait until quite the end of the month or the beginning of September, when, for about a week, there is a very marked falling off in the normal prevalence of gales.

Daily Prevalence of Gales.

The daily prevalence of gales is shown in Fig. 6, the perpendicular lines in which give, for the 30-year period, the number of times on which a gale occurred on each day in the year. The shaded lines at the base of each portion of the diagram give, in the same manner, the number of times on which a severe or partially severe gale was recorded. The maximum number of gales of all kinds on any one day was reached on January 8 and March 9, when a storm occurred in as many as 16 years. Inasmuch as this is little more than half the total number, it is quite clear that we cannot with any degree of safety predict the occurrence of a gale on any particular day in the year. The two days we have mentioned, and certain other days in the winter half-year, may, however, fairly be regarded as critical dates. On November 14 a gale occurred in 14 years out of the 30, and on January 3, 7, 23, and 31, February 10, and November 1 in 13 years, several other days in the winter time being distinguished by as many as 12. The maximum number of times on which a severe gale occurred was 7 on January 18 and 23 and February 10, but 6 were recorded on January 24 and 25, and on December 8 and 20. In the winter months proper—*i.e.* December, January, and February—there was, in the course of the 30-year period, no single day enjoying a complete immunity from a gale of some kind, but there were 5 on which there was no record of any severe storm. With some show of fitness one of the favoured five was Christmas Day (a time usually associated with peace and social harmony), the other dates being January 11 and February 17, 24, and 27. In the summer months there were naturally several days with a

complete immunity from gales of any kind, the larger number occurring in June and July. In the former month there were altogether 11 days, 3 of them being consecutive; in July there were only 8, but 4 were consecutive, the latter occurring between the 15th and 18th. The portion

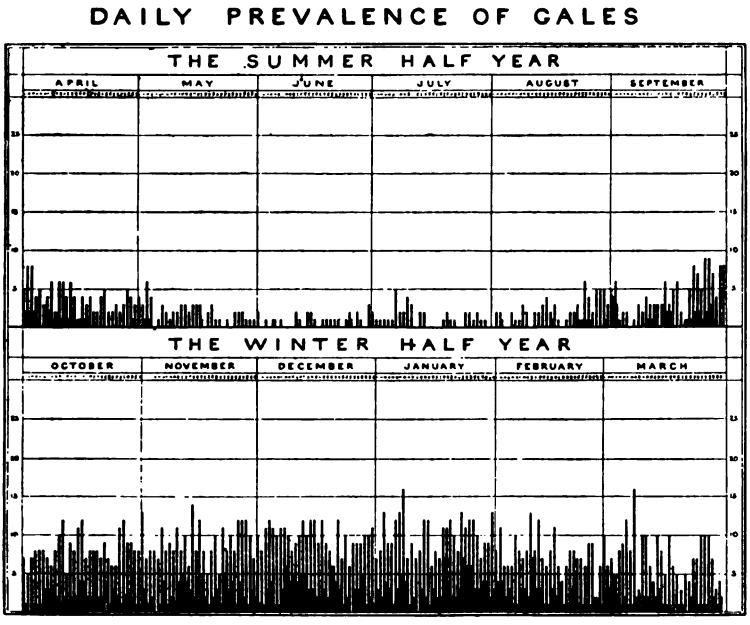


FIG. 6.

of the year in which storms were least prevalent was the end of May and the early part of June. From May 29 to June 10, a period of 13 days, there were only 8 days out of 390 with a gale of any kind on our coasts.

Long Periods of Quiet Weather.

The longest spell of quiet weather recorded during the 30 years was in 1893, when there was a complete absence of gales between March 16 and August 20, a period of about 5 months and a week. Next to this we find, in 1872, an absence of gales between May 5 and September 23, a period of 4 months and 3 weeks. In the summer of 1884 there was a stretch of 4 months between May and September without any gale, while in the summers of 1871, 1873, and 1889 a similar immunity was enjoyed for about 3 months and 3 weeks. The only other case worthy of note was in 1887, when a spell of quiet weather lasted from May 21 to August 31, a period of about three months and a half. In the winter half-year (October to March) the longest spell of quiet weather occurred between February and March 1872, when an absence of gales was experienced over a period of nearly 5 weeks. In the winter proper (December to February) the longest spells occurred between January and February 1875, when no gale occurred for 28 days; and in January 1880 and February 1886, when no gale occurred for a period of 27 days.

Direction of Wind in Gales.

In compiling our catalogue of gales the quarter from which the wind blew was in each case noted, the various cases being afterwards grouped under the eight principal points of the compass. The results for each year are given in percentage form in Table III., together with means for the entire period. In a large majority of instances the gales experienced in these islands form but part of a large atmospherical circulation round a cyclonic centre lying quite outside our area, the general direction of the wind being the same, or nearly the same, on all coasts. In some cases, however, the storm centre advances over the more central parts of the kingdom, and the cyclonic circulation is therefore complete, the gale blowing from various directions in different regions. In the table all gales of this kind are classed as "vortical" gales.

From the mean values given at the foot of Table III. we see that, of all the gales which occur on our coasts, no fewer than 62 per cent blow

TABLE III.—Proportion of Gales from Various Points of the Compass during each of the 30 Years 1871-1900.

Years.	Total No. of Gales.	Percentage of Gales from									Percentage of Gales from					
		N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Vortical Gales.	N. and N.E.	E. and S.E.	S. and S.W.	W. and N.W.	Arctic, or Polar, Directions, N.W., N., N.E., and E.	Atlantic, or Equatorial Directions, S.E. S., S.W. and W.
1871	41	5	5	8	12	22	24	10	7	7	10	20	46	17	25	68
1872	46	5	4	...	13	26	35	4	11	2	9	13	61	15	20	78
1873	31	3	3	7	...	13	26	23	19	6	6	7	39	42	32	62
1874	36	...	...	...	6	17	22	19	19	17	...	6	39	38	19	64
1875	34	...	6	12	14	21	12	12	14	9	6	26	33	26	32	59
1876	43	7	...	7	14	12	23	16	12	9	7	21	35	28	26	65
1877	57	5	5	9	9	19	23	9	18	3	10	18	42	27	37	60
1878	43	16	7	5	9	9	28	10	14	2	23	14	37	24	42	56
1879	51	2	8	9	14	12	27	14	10	4	10	23	39	24	29	67
1880	49	...	6	6	4	21	25	14	16	8	6	10	46	30	28	64
1881	50	2	10	12	12	18	14	12	8	12	12	24	32	20	32	56
1882	65	5	6	3	6	14	28	18	14	6	11	9	42	32	28	66
1883	59	9	5	5	8	22	17	15	14	5	14	13	39	29	33	62
1884	47	5	4	2	4	15	36	19	13	2	9	6	51	32	24	74
1885	55	6	7	5	5	20	24	15	9	9	13	10	44	24	27	64
1886	49	4	4	6	8	12	29	19	6	12	8	14	41	25	20	68
1887	34	3	6	...	9	15	32	17	9	9	9	9	47	26	18	73
1888	46	6	13	6	11	7	20	15	13	9	19	17	27	28	38	53
1889	29	7	4	3	...	7	21	17	31	10	11	3	28	48	45	45
1890	57	4	3	4	5	21	19	21	16	7	7	9	40	37	27	66
1891	54	4	2	4	9	17	22	18	13	11	6	13	39	31	23	66
1892	50	8	4	6	12	6	24	18	18	4	12	18	30	36	36	60
1893	46	13	6	4	4	11	24	11	20	7	19	8	35	31	43	50
1894	52	2	2	2	14	17	19	21	15	8	4	16	36	36	21	71
1895	49	8	8	6	19	4	21	16	16	2	16	25	25	32	38	60
1896	50	6	4	2	8	8	16	14	24	18	10	10	24	38	36	46
1897	63	5	3	6	11	18	24	13	14	6	8	17	42	27	28	66
1898	56	5	9	7	5	11	18	20	16	9	14	12	29	36	37	54
1899	52	2	...	2	13	12	23	21	17	10	2	15	35	38	21	69
1900	61	5	6	5	5	10	18	20	20	11	11	10	28	40	36	53
Means	48·5	5·0	5·2	5·1	8·9	14·6	23·0	15·7	14·7	7·8	10·2	14·0	37·6	30·4	30·0	62·2

from some Atlantic or equatorial direction, that is from points varying between South-east and West round by South. 30 per cent blow from some Arctic or polar quarter, that is from points varying between North-west and East, the remaining 8 per cent being of a vortical character, chiefly from equatorial directions in the South, and from polar directions in the North. The proportion of each kind varies greatly however, from year to year. The largest proportion of equatorial gales occurred in 1872, when no fewer than 78 per cent blew from such directions, only 20 per cent being from polar quarters, and only 2 per cent being classed as "vortical." The smallest proportion of equatorial gales was in 1889 (the least stormy year of the whole period), when the percentage was as low as 45; the proportion of polar gales in this year (also 45) was the largest shown in the record. Adopting a finer subdivision, we see from the table that the proportion of gales from North and North-east was highest in 1878, when it amounted to 23 per cent, or more than double the average; in 1874 there were no such gales, and in 1899 the percentage value was only 2. Gales from East and South-east attained their highest proportion (26 per cent) in 1875; the lowest proportion (3 per cent) occurred in 1889. Gales from South and South-west (the commonest type of all) were most prevalent in 1872, when the proportion was as high as 61 per cent; the lowest percentage, 24, was in 1896. Gales from West and North-west reached their highest proportion (48 per cent) in 1889; the lowest proportion (15 per cent) occurring in 1872. "Vortical" gales were relatively most numerous in 1896 when 18 per cent of all the storms partook of this character; the lowest percentage, 2, occurred in each of the years 1872, 1878, 1884, and 1895.

Table IV. gives the mean frequency of gales from various directions in each month and in each season of the year, the seasonal conditions being also shown graphically by the wind-roses in diagram, Fig. 7. It will be seen from the table that the highest proportion of equatorial gales (*i.e.* gales from South-east, South, South-west, and West) occurs in December and January, the proportion being, however, nearly as high in February; in each of these winter months more than two-thirds of our gales blow from some equatorial direction. The proportion is lowest (55 per cent) in March, but is also low in October, and somewhat low in November. The proportion of gales from polar quarters is greatest, singularly enough, in July, but the total number of storms in that month is so small that a more extended series of observations would probably be necessary before we could accept so startling a result as beyond all doubt. Next to July the greatest proportion of polar gales (nearly 41 per cent) occurs in March, and after that in April. The smallest proportion by far of polar gales (less than 20 per cent) occurs in December, and we therefore arrive at the somewhat paradoxical conclusion that cold-wind gales are most common in the warmest month, and least common in one of the coldest months of the twelve. The proportion of "vortical" gales is shown by our data to be greatest in June, but here again the total number of summer gales with which we have had to deal is too meagre to yield a conclusive result. Next to June the greatest proportion of such gales occurs in December, when nearly 12 per cent of our storms are due to cyclonic systems the centres of which advance directly over the United Kingdom.

In May and in each of the three Autumn months, September, October, and November, about 10 per cent of the gales are of this character; but in April the percentage is very little above 2, while in July such gales are non-existent. A more minute subdivision of the various directions from which gales blow in different months shows that:—

The proportion of gales from N. and N.E. is greatest in November, and least in June.

The proportion of gales from E. and S.E. is greatest in April; in June such gales may be said to be non-existent.

The proportion of gales from S. and S.W. is greatest in January, and least in April.

The proportion of gales from W. and N.W. is greatest in July, and least in November.

The wind-roses in diagram, Fig. 7 show the prevalence of gales from various directions in each of the four seasons of the year. The figures enclosed within each of the inner circles give the percentage of "vortical" gales, while the thick lines pointing towards these circles show the proportion of gales from each of the eight principal points of the compass. The length of these thick lines is determined by the outer circles, each of which, counting from the inner one, represents a portion of 5 per cent. For purposes of comparison with the general results the central wind-rose gives the proportion for the entire year.

TABLE IV.—Mean Proportion of Gales from Various Points of the Compass in each Month and in each Season of the Year.

Months.	Percentage of Gales from								Vortical Gales.	Percentage of Gales from				
	N.	N.E.	E.	S.E.	S.	S.W.	W.	NW.		N. and N.E.	E. and S.E.	S. and S.W.	W. and N.W	Arctic, or Polar, Directions, N.W., N., N.E., and E.	Atlantic, or Equatorial Directions, S., S., S.W., and
January	3·8	5·3	6·1	8·1	20·6	25·7	14·5	11·4	4·5	9·1	14·2	46·3	25·9	26·6	68·9
February	3·7	4·0	4·5	14·7	17·6	22·9	12·5	12·2	7·9	7·7	19·2	40·5	24·7	24·4	67·7
March	7·8	7·2	6·7	8·6	10·0	18·1	18·6	19·0	4·0	15·0	15·3	28·1	37·6	40·7	55·3
April	4·2	9·5	10·8	21·2	11·8	15·0	11·7	13·4	2·4	13·7	32·0	26·8	25·1	37·9	59·7
May	6·1	5·1	4·1	5·3	10·6	28·0	15·3	15·3	10·2	11·2	9·4	38·6	30·6	30·6	59·2
June	2·4	...	...	...	7·1	23·8	31·0	21·4	14·3	2·4	...	30·9	52·4	23·8	61·9
July	6·1	1·3	...	1·3	5·2	22·6	30·0	33·5	...	7·4	1·3	27·8	63·5	40·9	59·1
August	1·2	...	5·0	2·6	7·4	26·2	27·2	24·4	6·0	1·2	7·6	33·6	51·6	30·6	63·4
September	6·2	2·9	2·7	5·8	11·8	29·9	17·6	13·3	9·8	9·1	8·5	41·7	30·9	25·1	65·1
October	5·9	5·3	5·7	7·2	14·6	19·6	15·5	16·3	9·9	11·2	12·9	34·2	31·8	33·2	56·9
November	8·3	9·1	4·3	9·3	14·3	22·6	11·8	10·5	9·8	17·4	13·6	36·9	22·3	32·2	58·0
December	1·1	2·3	2·8	8·6	17·0	25·0	18·0	13·4	11·8	3·4	11·4	42·0	31·4	19·6	68·6
Spring	6·7	7·5	7·2	11·3	10·6	19·5	15·6	17·1	4·5	14·2	18·5	30·1	32·7	38·5	57·0
Summer	2·5	0·3	2·7	1·7	6·8	24·9	28·5	26·2	6·4	2·8	4·4	31·7	54·7	31·7	61·9
Autumn	7·0	6·4	4·5	7·8	13·9	23·0	14·0	13·6	9·8	13·4	12·3	36·9	27·6	31·5	58·7
Winter	2·8	3·9	4·8	10·5	18·5	24·5	14·6	12·4	8·0	6·7	15·3	43·0	27·0	23·9	68·1
Summer Half-year	4·8	4·2	4·8	8·4	10·2	24·3	18·9	17·5	6·9	9·0	13·2	34·5	36·4	31·3	61·8
Winter Half-year	5·0	5·4	5·1	9·5	15·9	22·5	14·7	13·6	8·3	10·4	14·6	38·4	28·3	29·1	62·6
Entire Year	5·0	5·2	5·1	8·9	14·6	23·0	15·7	14·7	7·8	10·2	14·0	37·6	30·4	30·0	62·2

It will be seen that, at all seasons of the year excepting the summer, the prevalence of gales from South-west is greater than from any other quarter. The minimum of such gales is reached in the Spring, when rather less than 20 per cent are from South-west, more than half the storms being, however, from points between South-west and North-west. The prevalence of gales from polar directions is then at its maximum, more

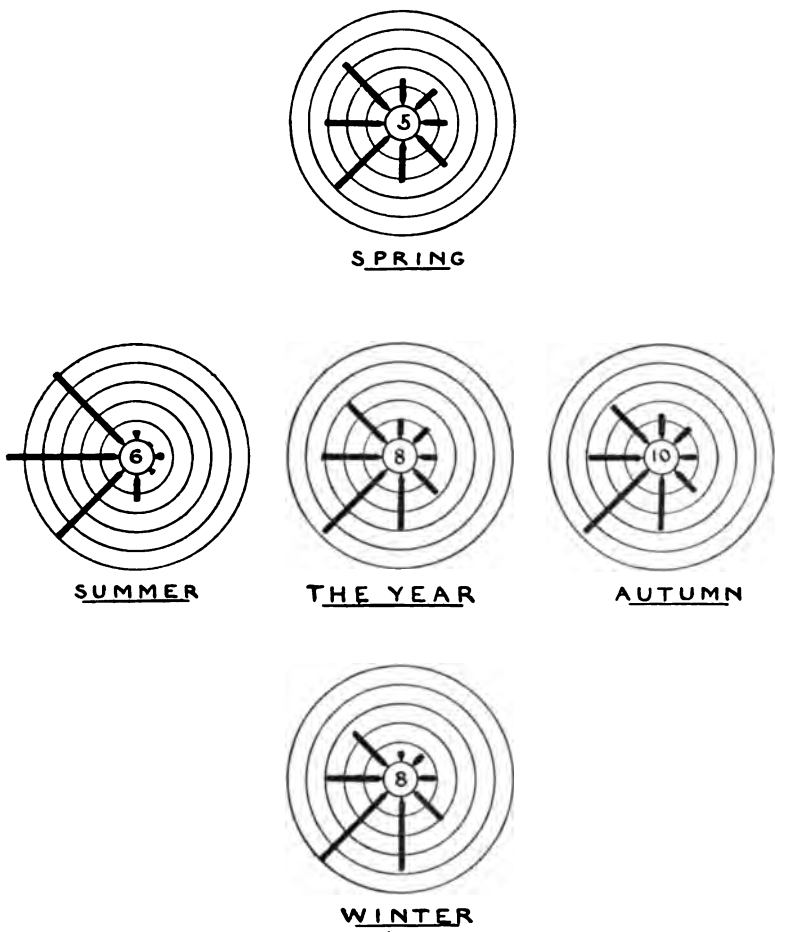


FIG. 7.—Relative Frequency of Gales from various points of the Compass.

than 21 per cent blowing from points between North and East; in the spring of 1883, out of a total of eleven gales no fewer than seven were from these quarters, the proportion being about three times the average. "Vortical" gales reach their minimum in this season of the year, the proportion being less than 5 per cent, as against an annual average of 8 per cent.

In the summer season gales from all points between North and South-east are very rare—those from North-east may, in fact, be said to be almost non-existent. The proportion of storms from South-west is as large as

in any other season. The most striking feature in the summer time is, however, the very large preponderance of gales from West and North-west, nearly 29 per cent blowing from the former direction, and more than 26 per cent from the latter; in many summers there were, in fact, no gales from any other but these two quarters. The proportion of Westerly gales in the summer season is nearly twice as great as at any other time in the year. "Vortical" gales are proportionately rather more numerous in the summer than in the spring, but the percentage value, 6, is 2 below the annual average.

In the autumn the results agree very closely with the average for the entire year. Gales from South-west are more common than those from any other direction, and nearly two-thirds of the whole number blow from points between South and North-west. The proportion of gales from East is about the same as in the winter, but gales from North and North-east are twice as numerous. "Vortical" gales reach their maximum in this season, the proportion being as large as 10 per cent, or 2 more than the annual average. In the autumn of 1894 more than a third of the gales experienced were due to cyclonic systems, the centres of which advanced directly over the United Kingdom.

In the winter the most common storms are those from South or South-west, nearly 19 per cent blowing from the former quarter and nearly 25 per cent from the latter; in the winter of 1871-72 (not a particularly stormy season) the percentage of gales from one or other of these directions was as large as 73. Gales from West and North-west are proportionately less frequent in the winter than in most other seasons, and true polar storms, that is gales from between North and East, are far less common than in the spring and autumn, the total percentage being only 12, as against 21 and 18. The proportion of "vortical" gales in the winter season (8 per cent) agrees almost precisely with the annual average.

Velocity of the Wind in Gales.

The anemometers by which the velocity of the wind is recorded in these islands are exposed under such varying conditions, and many of them so imperfectly, that it is impossible to institute any proper comparison between the results obtained from time to time and in different localities. In some places the instrument is so effectively sheltered by trees or buildings that its indications afford no guide whatever as to the strength of the wind in the surrounding open spaces. An examination of the records of such an instrument would in fact convey an impression that gales rarely, if ever, occurred in the town or neighbourhood it is supposed to represent. In other and more numerous instances the instrument is only partially sheltered, its indications being good for winds blowing from certain quarters, but quite misleading with the wind blowing in an opposite direction. In these cases an examination of the records would seem to show that gales, say from the Eastward, were quite as common as in other places, but that storms, say from the Westward, were scarcely ever experienced—a conclusion that might again be very wide of the mark. Any one unacquainted with these varying conditions would naturally assume that if in the course of a gale the velocity, say of 60 miles an hour, is recorded in one place, and a velocity of 30 miles in

another, the wind at the former station blew twice as hard as at the latter. In many cases the assumption would be altogether false, and for some stations one might go equally astray in comparing the records made at different times by winds blowing from different quarters, and by assuming that a Westerly gale of a velocity, say, of 30 miles an hour was of equal severity with one of a similar velocity blowing from another quarter. Owing to these variations in the value of the different records the figures we are about to quote must be accepted with a certain amount of reserve.

The form of anemometer from which records are taken for the official return of gales is the Robinson Cup, mostly of the larger pattern, with cups of 9 inches diameter, mounted on arms 24 inches long. Until a somewhat recent date it was assumed that with this pattern the cups revolved with one-third of the velocity of the wind, and the factor 3 was therefore employed in deducing the true velocity from the revolutions of the instrument. As a result, however, of experiments made by our President, Mr. W. H. Dines, and by Sir George Stokes, it was found that this factor was too high, and that the velocity of the cups should more properly be multiplied by 2·2. In the official records from which my storm data have been extracted the old factor 3 was alone employed, but as the point in question has long passed beyond the region of doubt, I have thought it advisable to reduce all velocities quoted in this paper to their proper equivalents. At one station, Scilly, an anemometer of a smaller pattern than the standard is employed, the cups being in this case 5 inches in diameter, and mounted upon arms 12 inches long. With this form of instrument the record gives a velocity corresponding closely with the truth; but in order to make the data strictly comparable, I have slightly reduced the figures by applying the factor 2·8, which I am assured is as nearly as possible the correct one.

As a result of a careful and exhaustive inquiry instituted a few years ago by Mr. Richard H. Curtis,[1] a list of velocity equivalents for the different forces of Beaufort's Wind Scale was calculated, the values being probably as accurate as any we are likely to get for a long time to come. According to these figures a mean velocity of 53 miles an hour is equivalent to a wind force of 10, the limit I have assigned as the definition of a severe gale. In the course of the 30 years there were 124 gales in which this velocity was exceeded at one or more of the stations, the proportion being less than 1 in 12 of the total number of gales, and considerably less than half the gales classed as severe, the degree of severity in the remaining cases being indicated only by estimation. The largest number of cases in any one year occurred in 1884, and again in 1899, when there were 9 gales in which this high velocity was registered. Next to these the worst years were 1881 with 8 cases, and 1882, 1894, 1897, and 1898, each with 7 cases. In 1879 there were none at all. It should, however, be mentioned that, in the earlier years of the period, the anemometrical representation in these islands was far less satisfactory than in the later years. Within more recent times greater care has been taken, when erecting new instruments, to ensure for them something like an adequate exposure, and in addition to this the positions of some of the older ones have been materially improved.

[1] "An attempt to determine the velocity equivalents of wind forces estimated by Beaufort's Scale." *Quarterly Journal Royal Meteorological Society*, vol. xxiii. p. 24.

For a wind force of 11 by Beaufort's Scale Mr. Curtis gives a mean velocity equivalent of 64 miles per hour. Table V. contains a list of all cases in which this very high velocity was exceeded in the 30-year period.

TABLE V.—Cases in which a Mean Wind Velocity exceeding 64 Miles an Hour was recorded in the British Islands during the 30 Years 1871-1900.

Station.	Date.			Direction of Wind.	Extreme Velocity.
	Year.	Day.	Hour.		
Sandwick (Orkneys)	1884	Jan. 20	9 a.m.	W by S	65
Scilly	,,	Dec. 20	4 a.m.	WNW	67
Scilly	1886	Oct. 16	6 a.m.	WNW	69
Scilly	1886	Dec. 8	3 p.m.	W by N	66
Fleetwood	1887	May 20	8 a.m.	NW	67
Scilly	1888	Mar. 11	5 a.m.	W	68
Scilly	1890	Jan. 23	9 a.m.	W by N	66
Scilly	1891	Nov. 11	8 a.m.	NW	70
Fleetwood	1891	Dec. 11	1 a.m.	NW	66
Deerness (Orkneys)	1893	Nov. 17	9 p.m.	N	70
Holyhead	,,	Nov. 18[1]	11 a.m.	N by W	65
Scilly	,,	Dec. 20	Noon	WSW	72
Fleetwood	1894	Feb. 12	5 a.m.	W by N	66
Fleetwood	,,	Dec. 22	9 a.m.	W	78
Scilly	1896	Dec. 13	10 p.m.	W by N	73
Scilly	1897	Mar. 3	6 a.m.	WNW	65
Fleetwood	,,	Nov. 29	1 a.m.	NW	65
Fleetwood	1899	Jan. 12	5 p.m.	WNW	76
Scilly	1900	Dec. 28[2]	8 a.m.	W by N	70

[1] A velocity of 64 miles was recorded also at Fleetwood at 10 a.m. on the same day.
[2] A velocity of 64 miles was recorded also at Fleetwood at 4 p.m. on the same day.

It will be seen that in 14 out of the 19 cases quoted the very high velocity was recorded in the earlier half of the day (before noon), and further, that in all but 2 instances the wind blew from some point between West and North, most of our very severe gales being due to a brisk rise of the barometer occurring in the rear of a deep depression. Judging by the anemometrical records, one of the worst gales of the whole period was that of November 17-18, 1893, when the wind blew from the Northward with a mean hourly velocity of 64 miles and upwards at three of the stations; in no other case was such a velocity recorded at more than two. The highest velocities of all registered during the 30 years were, however, those recorded at Fleetwood on December 22, 1894, and on January 12, 1899, the gale being in each case from the Westward. On the former occasion a mean velocity of 53 miles and upwards (equivalent to force 10 by Beaufort's Scale) was registered for 14 consecutive hours. For 9 hours, from 7 a.m. to 3 p.m., the velocity was at least 64 miles (force 11), and at 9 a.m. it reached a maximum of 78 miles, being 1 higher than the equivalent force of 12 (a hurricane). At 10 and 11 a.m. the velocity was almost as great as at 9 a.m. On the latter occasion (January 12, 1899) the gale was almost as severe as that of 1894, but was of shorter duration. A mean hourly velocity of 53 miles and upwards was, however registered for 6 hours from 4 p.m. to 9 p.m., and at 5 p.m. a maximum of 76 miles was recorded, the rate being as high as 70 miles at 6 p.m.

The values just quoted are, it must be clearly borne in mind, the mean rate at which the wind travels for a complete hour. The velocity in squalls is of course quite a different matter, and inasmuch as the bulk of the damage in a severe gale is due to these passing gusts, the question is one of great interest, especially from an engineering point of view. With the records yielded by the Robinson form of anemometer the measurements of squalls is unfortunately by no means an easy task. The recording trace, which is made by a somewhat blunt pencil upon metallic paper, is often thick and sometimes rather indistinct, and when the trace runs almost perpendicularly, as it does in very high winds, it is extremely difficult to pick out in detail the portions in which the wind is travelling most rapidly.

With the Pressure-Tube Anemometer invented by Mr. Dines, and now coming into fairly extensive use, the passage of each squall is shown with admirable distinctness, and an examination of the curves of such an instrument yields much valuable information as to the behaviour of the wind in gales of different strengths and blowing from various directions. During the 30-year period under review the highest velocity recorded in these islands by such an instrument was, so far as I am aware, during the gale of March 3, 1897, when a squall reaching the velocity of 101 miles per hour was registered by the pressure-tube anemometer at Rousdon, Lyme Regis. This was at about 8.45 a.m., and on referring to Table V. we see that, at 6 a.m. on the same day, a mean hourly velocity of 65 miles was recorded at Scilly, about 150 miles to the West-South-westward of Rousdon.

Barometric Gradients in Severe Gales.

The strength of the wind depends, as is well known, upon the steepness of the barometric gradient, or in other words, of the slope that is supposed to exist in the atmosphere between a place in which the barometer is relatively high and a place in which it is at the same time relatively low. The relation between these two elements varies, however, to such an extent that it is quite impossible to say that, with a given gradient, the wind will necessarily blow with a given degree of strength. Much depends, it is certain, upon the direction in which the gradient lies, the wind being usually much stronger with an Easterly than with a Westerly gradient of the same degree of steepness. Something may also be attributed to the conformation of the country over which the wind has to pass, a steep gradient over a hilly surface being usually accompanied by a lighter wind than exists with a similar gradient over a plain, where the flow of air has little to impede it. From an examination of more than 300 cases I am inclined to say that it is quite possible for a severe gale to blow with any gradient exceeding 0·25 in. per 100 geographical miles.

The examination in question has comprised a careful measurement of the steepest gradient existing during each of the severe and partially severe gales of the 30-year period. For this purpose I have used the daily weather charts prepared in the Meteorological Office. These charts are drawn only thrice daily, viz. for 8 a.m., 2 p.m., and 6 p.m., and it is therefore highly probable that in some cases a steeper gradient may have

existed during a gale than anything shown at those fixed hours. With regard to one storm this was certainly the case. In order to obtain a representation of the distribution of pressure existing at the time when the barometer in these islands fell to the lowest point on record, I drew specially a weather chart for 9 p.m., and incidentally succeeded in finding a gradient steeper than anything yielded by the maps drawn for the usual hours of observation. The case in question occurred at 9 p.m. on January 26, 1884, when the barometric gradient over the South-west of Scotland, the North Channel, and the extreme North of Ireland amounted to no less than 0·7 inch per 100 geographical miles.

Cases in which the barometric gradient was as steep as 0·6 inch per 100 miles occurred on the following dates and in the following localities :—

1874. October 21, 8 a.m. Scotland and the adjacent parts of the North Sea.
1880. November 26, 8 a.m. West and North of Ireland.
1881. October 14, 2 p.m. South of Scotland and the extreme North of England.
1886. December 8, 8 a.m. West of Ireland.
1890. January 19, 8 a.m. North of Ireland.
1893. December 8, 8 a.m. and 2 p.m. Scotland and the North of Ireland.
1894. December 22, 8 a.m. Extreme North of England.
1900. December 20, 6 p.m. West of Ireland.

These cases occurred without exception during the prevalence of general and severe gales and over some part of our Western and Northern coasts. Numerous instances in which the barometric gradient was as steep as 0·5 inch per 100 miles were observed in the same districts, but I have not found more than three cases in which such a gradient existed over the South-eastern portions of the kingdom or their immediate neighbourhood. One of these occurred during the violent Easterly gale and snowstorm of January 18, 1881, and was measured over the Midland and a portion of our Southern counties; this was apparently the steepest Easterly gradient experienced during the whole 30 years. Another case occurred on December 8, 1886, at 8 a.m., when a gradient of 0.5 inch per 100 miles existed over a considerable portion of England and Ireland. The third instance was observed at 6 p.m. on December 26 of the same year, when a deep cyclonic system moved Eastwards along the Channel and occasioned heavy snowstorms in the South of England; the very steep gradient of 0·5 inch was measured in this case over the eastern parts of the Channel and the north-east of France.

The steepest gradient observed in any of the summer months, June to August, was one of 0·35 inch per 100 miles, which occurred at 6 p.m. on August 3, 1900, over the western and central parts of England. During the progress of this storm the wind attained a mean hourly velocity (true) of 50 miles at Fleetwood, of 45 miles at Kingstown, and of 44 miles at Holyhead, the force by Beaufort's Scale being estimated by several observers as 10. In four other cases a gradient of 0·3 inch per 100 miles was observed in connection with summer gales, one of the most important instances occurring over the North of Scotland on June 25, 1890. In this case a mean hourly velocity of 54 miles was reached at Swanbister in the Orkneys, and an estimated force of 11 at Wick, the gale (which blew from the Westward) being attended by serious damage to the fishing fleets and considerable loss of life.

Movements of Important Storm Systems.

1. *Direction of Movement.*

An enquiry into the various features of interest in connection with the important storm systems of the period, *i.e.* such disturbances as were attended by severe or partially severe gales, comprised, in addition to the measurement of the barometrical gradients, an examination of the path of each storm centre, its direction and rate of movement, and the regions traversed during its progress over these islands or their immediate neighbourhood.

As a result of these enquiries it would appear that on an average and taking the whole year through, 43 per cent of the storm systems which visit our coasts advance from some point of the compass lying between South and South-west, and travel towards some point lying between North and North-east. Of this class by far the larger proportion, *i.e.* 28 per cent out of the 43, travel from South-west to North-east. 39 per cent of our storms have an Easterly motion, their centres moving from some point between West-south-west and West-north-west towards some point between East-north-east and East-south-east, and of these the larger proportion (18 per cent) travel from West-south-west to East-north-east. 12 per cent of the storms advance from some point between North-west and North, and travel towards some point between South-east and South, the bulk of these (8 per cent) moving from North-west to South-east. Less than 3 per cent of our storms move in a North-westerly direction, *i.e.* from points between East-south-east and South-south-east to points between West-north-west and North-north-west; and less than 1 per cent move Westwards or South-westwards, *i.e.* from points between East and North-north-east to points between West and South-south-west. Rather more than 3 per cent of the storms have, however, an irregular movement, and in this class we include cases in which the storm centre during its passage over North-western Europe changes its course by more than four points.

The seasonal variations in the direction of movement of storm systems are considerable. In the spring time, comprising the months of March, April, and May, only 31 per cent of the storms move in a Northerly to North-easterly direction, as against an annual average of 43 per cent. The percentage of storms moving Eastwards is, on the other hand, as high as 53, and exceeds the annual average by 14. The proportion of storms moving in other directions corresponds closely with the annual values, but the number of such cases occurring in the 30-year period was too small to yield any very reliable results.

In the autumn, comprising the months of September, October, and November, the state of things is almost completely the reverse of that shown in the Spring. 53 per cent of our autumn cyclones move in a Northerly to North-easterly direction, as against an annual average of 43 per cent, and only 29 per cent in an Easterly direction, as against an annual average of 39 per cent. The proportion of autumn storm systems moving in other directions again corresponds very closely with the annual average.

In the winter season, comprising the months December, January, and

February, an equal proportion (40 per cent) of the storm systems travel in a Northerly and North-easterly and in an Easterly direction. The proportion of storms travelling South-east or South is about the same as at other seasons of the year, but the proportion travelling from East or South-east towards West or North-west is in excess of the annual average, the same remark applying to storms moving in irregular paths.

2. *Rate of Movement.*

The centres of many of the larger cyclonic disturbances move along in paths lying quite outside our area of observation, so that, while the direction of movement can be usually determined with a fair approach to accuracy, it is often quite impossible to plot the varying positions of the centres and to measure their rate of travel. As a result of this uncertainty I found that, while the direction could be made out in the case of 311 important storm systems, the rate could be determined in only 267 instances. A mean of these 267 cases shows that the deep cyclonic systems which visit our islands travel on an average at the rate of 24·1 geographical miles per hour. The variations in the rate are, however, so tremendous that a mean in this, as in the case of some other meteorological elements, is of little practical value. Numerous instances could be cited in which a storm centre did not move at a rate of more than 8 or 10 miles per hour; while in several cases, which we shall quote presently, the rate amounted to 40, 50, or even 60 miles per hour.

The rapidity of movement varies somewhat at different seasons of the year. According to the figures before me it is greatest in the summer time; but inasmuch as there were in the course of the whole 30 years only 7 summer gales which could be classed as severe, the observations are obviously quite insufficient to enable one to attach much importance to the result. Leaving the summer out of the question, we find, as against an annual average of 24·1, a mean rate of travel of only 21·7 miles per hour in the autumn, and of 23·4 miles in the spring, but of 25·4 miles in the winter. On an average, therefore, our autumn storms travel at the slowest, and our winter storms at the quickest pace.

The mean results for the whole year show that the maximum rate of movement, 25·1 miles per hour, is attained by storms moving in an Easterly direction, *i.e.* from points between West-south-west and West-north-west towards points between East-north-east and East-south-east. Storms moving Northwards or North-eastwards, and those moving Southwards or South-eastwards, travel in each case at a mean rate of about 24 miles per hour, and may therefore be said to move with an average degree of celerity. Storms that move in irregular paths also move at very irregular rates, the mean of the comparatively few cases I have been able to examine being 19·1 miles per hour. The rare instances of storms moving in a North-westerly direction give a mean rate of 13·4 miles per hour, the slowest rate of all being, however, attained by storms moving South-westwards, the mean rate in these cases being only 10·7 miles per hour.

During the 30-year period there were 60 cases in which the storm centre travelled at the rate of more than 30 geographical miles per hour. Of these swiftly-moving storm systems, 25 travelled at the rate of between

31 and 35 miles, 14 at the rate of 36 to 40 miles, 11 at the rate of 41 to 45 miles, and 4 at the rate of 46 to 50 miles. The remaining 6 cases included 3 moving at the rate of between 51 and 55 miles, 2 at the rate of 56 to 60 miles, and 1 at the rate of 62 miles. The excessively rapid rate of 62 miles was attained by a small secondary cyclone, which travelled in an East-north-easterly direction across Ireland, England, and the North Sea on March 24, 1895. At 8 a.m. on that day the centre was over the south of Ireland, near Kilkenny; by 2 p.m. it was near Whitby, and by 6 p.m. it had reached Denmark.

Regions traversed by the Centres of Important Storm Systems.

As the result of an examination of nearly 320 cases, it appears that 61 per cent of the storm centres observed in the neighbourhood of these islands move in tracks lying outside our coasts. Of these the largest proportion (21 per cent of the total number) skirt the north of Scotland. An additional 16 per cent travel in a North-north-easterly direction (roughly estimated) outside our western and northern coasts, while 5 per cent pursue a somewhat more easterly course, the centres in these cases travelling past the north of Ireland and the west and north of Scotland. Nearly 6 per cent of the storm centres pass across the North Sea, usually in a South-easterly direction, while 5 per cent move Eastwards and South-eastwards across Scandinavia or Denmark, or across both countries. Rather more than 4 per cent skirt our extreme South-west coasts, while rather more than 3 per cent travel along the English Channel, or over the neighbouring parts of France.

In 39 per cent of the cases the storm centre advances directly over some portion of the United Kingdom. The larger proportion of these (16 per cent) pass across our northern districts, *i.e.* over Scotland or the extreme northern parts of England and Ireland; but an almost equal proportion (14 per cent) move further south, the centre traversing the more central parts of Ireland and England. Rather more than 4 per cent cross our southern districts, while $3\frac{1}{2}$ per cent travel over our western and northern districts, the bulk of these moving North-eastwards over Ireland and Scotland. The cases in which the centre traverses the northern and eastern parts of the kingdom are very rare (little more than 1 per cent of the entire number), while instances in which the centre crosses the south-western districts only are almost entirely wanting.

The cases in which the storm centre keeps outside our coasts are most numerous in the winter and least numerous in the autumn. In the former season the percentage of such cases is 65, or 4 more than the general average, while in the latter season it is only 55, or 6 less. In the winter season, in fact, nearly two-thirds of the storm centres keep outside our coasts, while in the autumn little more than half the number follow such tracks. In the spring the proportion of each class corresponds more closely with the yearly average. The summer cases are too few in number to admit of safe generalisation.

From an examination of the rate at which the two different classes move, it would appear that the storm centres which advance directly over us travel somewhat more rapidly than those which move outside our shores. An average of nearly 270 cases gives for the former class a

mean rate of about 25 geographical miles per hour, but for the latter a mean rate of little more than 23 miles. In the former class the fastest moving storm systems are those whose centres move across our northern and eastern districts, usually in a South-easterly direction, the mean rate in these cases being 28 miles per hour. Next to these the swiftest are those which cross the central or southern parts of the kingdom, when the mean rate is in each case rather more than 26 miles per hour.

Of the storm centres which keep outside our coasts the swiftest are those which pass across Scandinavia and Denmark, the mean rate of motion in these cases being nearly 28 miles per hour. Next to these come the storms which skirt our western and northern coasts, with a mean rate of nearly 25 miles; and next again the storm centres which skirt the north of Scotland or keep out in the North Sea, the mean rate of travel being in each case rather more than 23 miles per hour.

The slowest moving storm centres are in each class those observed in the south-western portions of the kingdom. In the very rare cases in which the centre actually traverses those districts the mean rate of motion is only 15 miles per hour, while in the more numerous instances in which it keeps outside the mean rate is less than 13 miles. In the latter cases the direction of motion is very variable, but usually either South-eastwards or North-westwards.

Some Notable Gales of the Period.

As a conclusion to this paper a series of weather maps has been drawn showing the progress of some of the most notable gales of the 30-year period. These gales have been selected, not always on account of their severity (some of the worst gales of the period are in fact unrepresented), but usually as typical of various kinds of storms, and in a few instances as of historic interest on account of the disastrous effects by which they were attended. The isobars are drawn in each case for every two-tenths of an inch, so that by comparing the different maps one gets a fair idea of the relative steepness of the gradients. The wind direction is shown by arrows flying with the wind, and its force by barbs and feathers, thus:— ←——, a light or moderate breeze; ←——, a fresh or strong breeze; ←—←, a fresh to strong gale (force 8 or 9 by Beaufort's Scale); and ←—←—←, a severe gale (force 10 and upwards). In the case of each gale a line of crosses has been drawn, showing the track pursued by the storm centre in its progress across North-western Europe, the position of the centre at the various hours of observation being shown by a dot with an accompanying date.

MARCH 24, 1878, 8 A.M. AND 6 P.M.—*The "Eurydice" Gale* (Figs. 8 and 9).—This was a sporadic gale, and was due to a "V-shaped" trough of low pressure of a rather ill-defined character which moved South-eastwards across the kingdom. The steepest gradient observed was only 0·2 inch per 100 miles, the highest mean hourly velocity of the wind recorded being 44 miles per hour at Holyhead. The North-westerly squalls in the rear of the low pressure system were, however, sharp and sudden, and in one of these the ill-fated training ship H.M.S. *Eurydice* foundered off Dunnose Head, near Ventnor, the loss of life amounting to about 300. The squalls were accompanied in many cases by showers of snow

or sleet. An examination of the origin and progress of this series of squalls was instituted by the late Hon. Ralph Abercromby.[1]

FIG. 8.

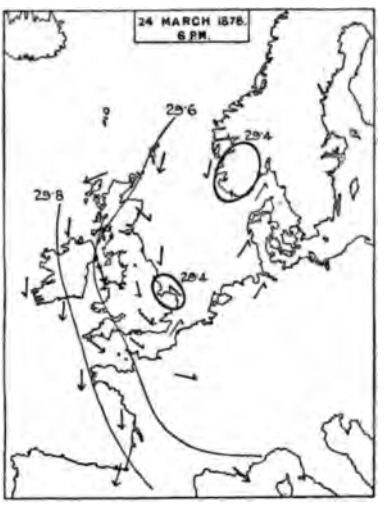


FIG. 9.

DECEMBER 28, 1879, 6 P.M.—*The Tay Bridge Storm* (Fig. 10).—On the evening and night of December 28 the centre of a deep cyclonic system skirted the north-west and north of Scotland, moving North-eastwards, its progress being attended by severe gales from West and South-west in many of our western and northern districts. At 6 p.m. the gradient over the west and south of Scotland amounted to 0·4 inch per 100 miles, and at 7 p.m. a mean hourly velocity of 45 miles was recorded at Alnwick Castle. At Aberdeen and Glasgow the mean hourly velocity did not exceed 43 miles, but in the squalls the rate was much higher. Dr. Scott estimated that, at the former station, the wind between 7·15 and 7·20 p.m. was blowing at the hourly rate of 70 miles (true), and that at Glasgow between 7·15 and 7·18 p.m. an hourly rate of 88 miles was reached, another squall passing over the same station between 8·43 and 8·46 p.m. giving an hourly rate of 81 miles.[2] It was in one of these squalls that a huge gap some 3000 feet long was made in the Tay Bridge, a passing North British mail train being engulfed, with a loss of life amounting to not less than 75, and possibly to as many as 90.

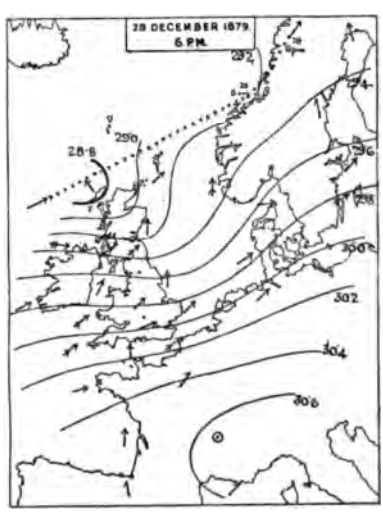


FIG. 10.

[1] See *Quarterly Journal Royal Meteorological Society*, vol. x. p. 172.
[2] *Quarterly Journal Meteorological Society*, vol. vi. p. 99.

JANUARY 18, 1881, 8 A.M.—*A Violent Easterly Gale and Snowstorm* (Fig. 11). —This gale was caused by a cyclonic system, the centre of which advanced North-eastwards across the Bay of Biscay and the north-west of France on the night of January 17.[1] Throughout the 18th the centre moved slowly and in a rather irregular manner over the central parts of the English Channel, but on the following day it travelled quickly away to Germany. At 6 p.m. on the 18th the barometric gradient over our midland and a portion of our southern counties was as steep as 0·5 inch per 100 miles, this being, as we have already seen, the steepest easterly gradient observed during the whole 30 years. The highest mean hourly velocity attained during the gale was at Yarmouth, where a rate of 59 miles was recorded at 11 a.m. Mr. Richard H. Curtis estimated, however, that at the same station the wind blew in one quarter of an hour between 3 and 4 p.m. at the hourly rate of 73 miles (see *Quarterly Journal Meteorological Society*, vol. vii. p. 213). At Kew, where the anemometer is in a somewhat sheltered position, a mean hourly rate of 43 miles was attained at 1 p.m.—an unusually high figure for that locality. The gale was accompanied by heavy snowstorms over nearly the whole of England, and in many places the railway lines were completely blocked for many hours. In the metropolis the snowstorm was the worst experienced within living memory, and owing to the high wind curious drifting effects were witnessed, the streets being in some cases perfectly clear on one side, but heavily banked with snow on the other.

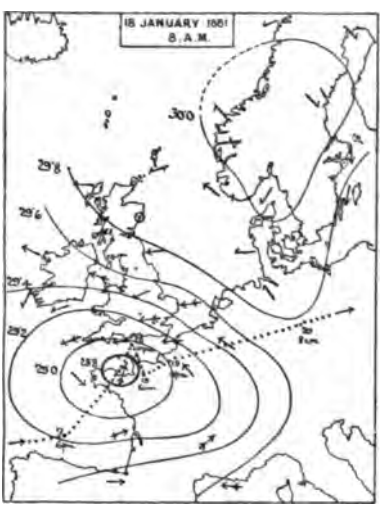


FIG. 11.

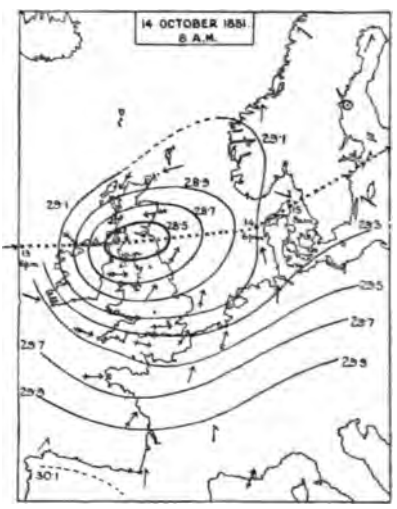


FIG. 12.

OCTOBER 14, 1881, 8 A.M.—*A Severe Autumn Gale* (Fig. 12).—This, one of the most severe gales of the whole period, was caused by a very deep storm system, the centre of which travelled in an East-north-easterly direction across the extreme north of Ireland and the south of Scotland, and afterwards across the North Sea, Denmark, and the south of Sweden to the Baltic. At 2 p.m. on the 14th a gradient of 0·6 inch per 100 miles was observed over the south of Scotland and the extreme north of England. The highest mean hourly velocities of wind attained were 59 miles at Scilly at 6 a.m. from the Westward, and

[1] In a paper read before this Society in June 1885, Mr. Charles Harding showed that this storm reached us from the other side of the Atlantic, its centre leaving the neighbourhood of New York on January 10. (See *Quarterly Journal Royal Meteorological Society*, vol. xi. p. 296.)

54 miles at Aberdeen at 10 a.m. from the North-eastward, but force 11 by Beaufort's Scale was reported by many observers from nearly all parts of the kingdom. The storm occasioned great loss of life at sea and some loss even on land; in London alone eight deaths were attributed to the effects of the gale. Much structural damage occurred, and in many districts there was a wholesale uprooting of trees, the destruction being greatest very naturally in the south of Scotland and the north of England, where the barometric gradient was steepest. (A full account of this gale and its effects, by Messrs. G. J. Symons, Charles Harding, and J. Wallace Peggs will be found in the *Quarterly Journal of the Meteorological Society*, vol. viii. pp. 1-34.)

APRIL 29, 1882, 6 P.M.—*A Destructive Spring Gale* (Fig. 13).—This gale occurred during the progress of a deep cyclonic system North-eastwards across England, and was unusually severe for so late a period in the spring, a mean hourly velocity of 50 miles being recorded at Falmouth (at 1 p.m.) and a velocity of 45 miles at Babbacombe. At 6 p.m. on the 29th the barometric gradient over the south-east of England was as steep as 0·4 inch per 100 miles. The gale blew from South-west and West, and was general over the south and east of England and the north of France. Much damage was done to the young spring foliage, the leaves being in many cases completely blackened, as though singed by fire. This effect was probably due to mechanical injury caused by the high wind, but was attributed by some observers to the action of sea salt, crystals of which were clearly traceable upon many of the leaves. Similar deposits have been observed during the prevalence of other gales, and frequently at very considerable distances from the sea.

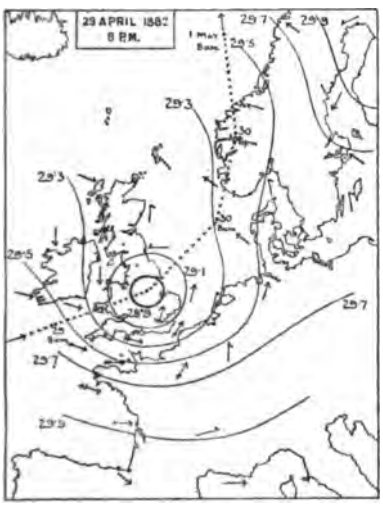


FIG. 13.

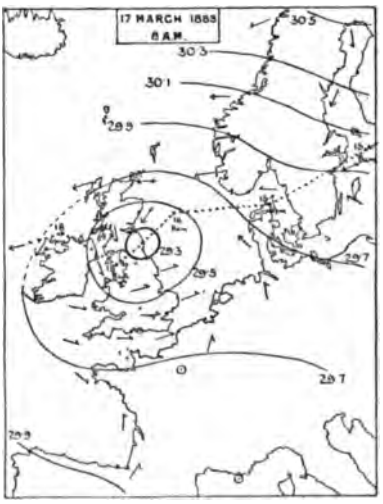


FIG. 14.

MARCH 17, 1883, 8 A.M.—*A Storm System moving Westwards* (Fig. 14).—This was a genuine example of a storm centre advancing from the eastward, and moving somewhat irregularly but in a *westerly* direction right across our islands, a very rare occurrence, as we have already shown. During its progress the gradients over the southern parts of our area were slight, but in the north they were much steeper, one of 0·3 inch per 100 miles being observed over the north and east of Scotland at 8 a.m. on the 17th. Strong East and North-east gales were experienced in the latter districts, the wind attaining a mean hourly

velocity of 45 miles at Aberdeen, and of 43 miles at Sandwick, in the Orkneys. The gales were accompanied by considerable falls of snow.

JANUARY 26, 1884, 9 P.M.—*A Storm System with a phenomenally Low Barometer* (Fig. 15).—This storm, which was general and very severe, was rendered memorable by the fact that, during the progress of the centre across Scotland, the barometer fell to the lowest level ever recorded in these islands, the lowest authentic reading being one of 27·332 ins. at Ochtertyre at 9·45 p.m. on the 26th.[1] Our weather map for 9 p.m. on that day shows that the isobar of 27·4 ins. enclosed nearly all the more central parts of Scotland, the barometric gradient over the south-west of Scotland and the extreme north of Ireland amounting at the same hour to no less than 0·7 inch per 100 miles. Over England and Ireland the gale was from the South-westward and Westward, but in Scotland the wind blew with equal fury from the South-eastward as the storm centre advanced, and from the Westward and North-westward in its rear. The highest mean hourly velocities attained were 56 miles at Alnwick Castle at midnight on the 26th, 51 miles at Holyhead at 2 p.m. on the same day, and 51 miles at Armagh at 5 p.m. At the last mentioned station the anemometer is not well exposed, and the velocity of the wind over the district generally must have been much higher than that shown by the record. (A complete discussion of this storm, by Mr. W. Marriott, will be found in the *Quarterly Journal Royal Meteorological Society*, vol. x. p. 114.)

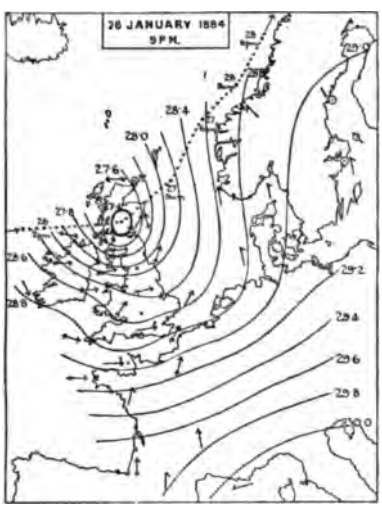


FIG. 15.

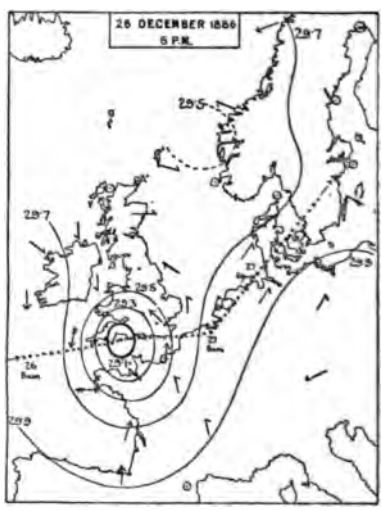


FIG. 16.

DECEMBER 26, 1886, 6 P.M.—*The Gale and Snowstorm of Boxing Day* 1886 (Fig. 16).—This gale was due to a small but deep disturbance, the centre of which advanced in an east-north-easterly direction along the English Channel on the 26th, and which afterwards moved away north-eastwards to Denmark and the south of Sweden. At 6 p.m. on the 26th the barometric gradient over the eastern parts of the Channel and the north-east of France amounted to 0.5 inch per 100 miles. The highest mean hourly velocity recorded was 45 miles

[1] During a severe storm on December 8-9, 1886, the barometer fell almost as low, a reading of 27·38 ins. being recorded on December 8 at Belfast, and readings below 27·5 ins. at many other stations in the north of Ireland. (See a paper by Mr. Charles Harding, *Quarterly Journal Royal Meteorological Society*, vol. xiii. p. 211.)

at Falmouth at 7 p.m., the wind being then from the Northward, in the rear of the depression ; at many of the Channel stations force 10 by Beaufort's Scale was reported. The principal feature in connection with the disturbance was, however, the heavy falls of snow which occurred over our southern districts. The snow was in this case very wet, and was in marked contrast with the dry powdery flakes observed during the great storm of January 1881. Clinging, as it did, to the telegraph wires, it soon caused an immense amount of destruction, the interruption to this means of communication being one of the most serious on record.

MARCH 9-11, 1891.—*Heavy Gales and Snowstorms in the West of England* (Figs. 17-19).—This gale was very similar in its general features to that of

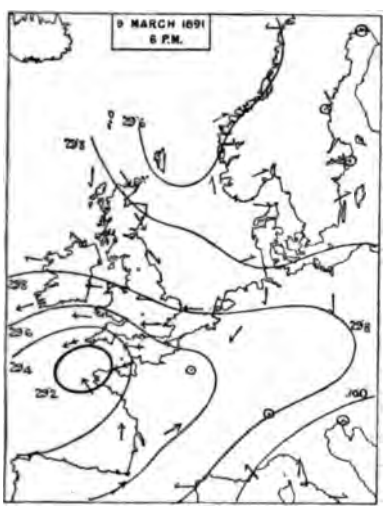


FIG. 17.

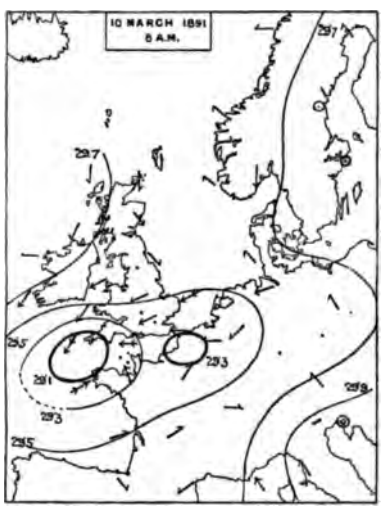


FIG. 18.

January 18, 1881, but its worst effects were confined to a far more limited area, the extreme southern districts being alone influenced. In the eastern portions of these districts both wind and snow were less violent than in the case of the 1881 storm ; in the western portions they appear to have been more severe. In this, as in the earlier instance, the centre of a deep cyclonic system advanced north-eastwards over the Bay of Biscay, its centre being shown at 8 a.m. on the 10th at the mouth of the English Channel. Later in the day the disturbance moved very slowly eastwards, but at night its progress became very brisk, the centre being over Belgium by the morning of the 11th. Another cyclonic area had in the meantime been formed over that country, but with the advance of the earlier disturbance this moved away to the eastward. At 8 a.m. on the 10th the barometric gradient over the Bristol Channel and the extreme south-west

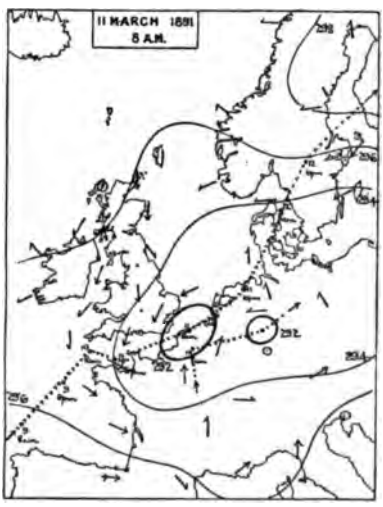


FIG. 19.

of England amounted to 0·45 inch per 100 miles, the greatest mean hourly velocity of the wind being registered at Scilly at 10 p.m. on the 9th and 1 and 2 a.m. on the 10th, when 53 miles was recorded. At many stations in the English and Bristol Channels the wind on the evening or night of the 9th reached force 10 by Beaufort's Scale, its direction being in every case East or East-north-east. Snow fell over the south of England generally, and in tremendous quantity over Cornwall and Devonshire, where excessively deep drifts were formed, causing much inconvenience and great delay to traffic.

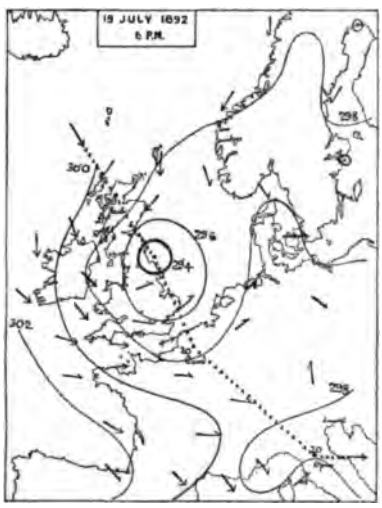


FIG. 20.

JULY 19, 1892, 6 P.M.—*A Northerly Gale in the Summer Time* (Fig. 20).—A general gale in July is, as we have already seen, an unusual occurrence, and a general gale from the Northward is certainly a curiosity. Such an event was recorded, however, in 1892, when the centre of a rather deep disturbance advanced over Scotland from the North-westward, and travelled in a south-south-easterly direction along the east coast of England, the system afterwards moving South-eastwards to Northern Italy. During its progress the wind blew with the force of a strong gale on many parts of the English and Irish coasts, the highest mean hourly velocity being registered at Fleetwood, where 48 miles was recorded from North-west at 3 p.m. and from North-east at 11 p.m. on the 19th.

NOVEMBER 16-18, 1893.—*A Southerly and South-easterly followed by a Severe Northerly Gale* (Figs. 21-24).—This storm, which was fully discussed by Mr. Charles Harding at the time (*Quarterly Journal Royal Meteorological Society*, vol. xx. p. 43), was quite an unique example of a general Southerly and a general Northerly gale occurring during the progress of the same cyclonic system. On the evening of November 16, when a large anticyclone existed over Russia, the centre of a deep depression appeared off the south of Ireland. Following the ordinary rule, by which such systems always keep the dominant high pressure to their right, the centre afterwards travelled in a north-north-easterly direction across Ireland and Scotland, its progress being attended by South-easterly to Southerly gales on all coasts. The highest mean hourly velocity of the wind recorded was at Holyhead, where 47 miles was attained at 10 p.m. on the 16th, several observers on the shores of the Irish Sea estimating the extreme force as 10 by Beaufort's Scale. By 6 p.m. on the 17th the storm centre had reached a position a little to the eastward of Wick. The Russian anticyclone had in the meantime drifted further to the eastward. A rapid rise of the barometer now took place on our western coasts, in which region the borders of a new anticyclone soon made their appearance. The influence of this system was very marked. Still following the law by which the motions of cyclones are governed, the storm centre completely changed its course, and instead of moving North-north-eastwards, travelled South-south-eastwards along the east coast of Great Britain, and thence on to Belgium and Western Germany, where the system appears to have dispersed early on the 19th. Owing to the rapid rise of the barometer in the west a very steep northerly gradient was formed (the difference

in pressure amounting to as much as 0·45 inch per 100 miles in many districts), and a gale of unusual severity from that quarter burst with great suddenness over the whole Kingdom. The highest mean hourly velocity recorded was 70 miles at Deerness (Orkneys) at 9 p.m. on the 17th, but a velocity of 65 miles was recorded next morning at Holyhead, and a velocity of 64 miles at Fleet-

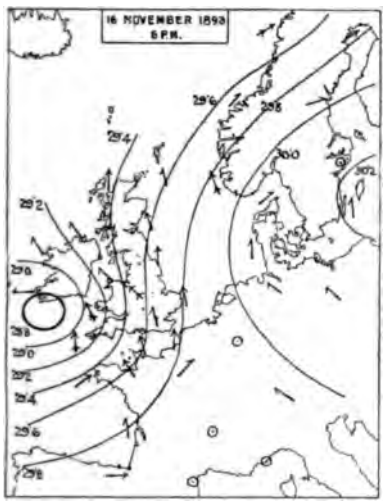
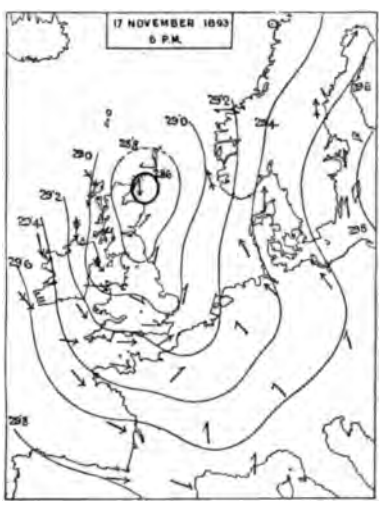


FIG. 21.



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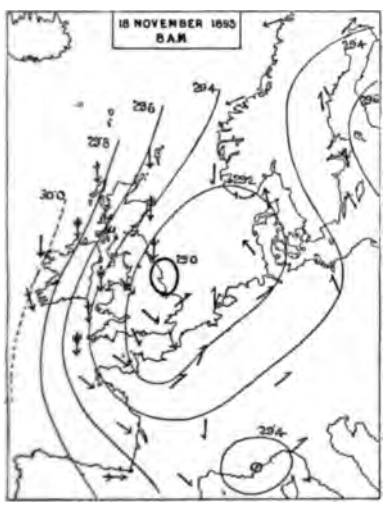

FIG. 23.

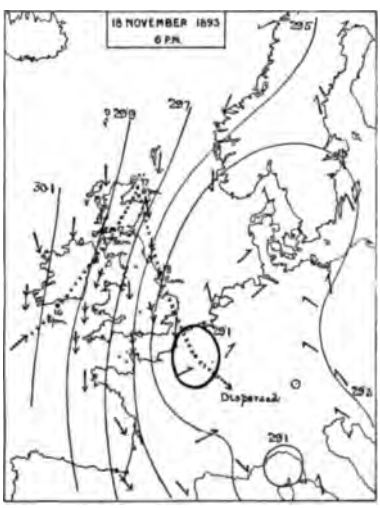

FIG. 24.

wood, observers in nearly all parts of the kingdom estimating the extreme force as 10 or 11, and some few observers as 12 by Beaufort's Scale. The storm occasioned great loss at sea, more than 300 lives being sacrificed, and much damage on land, especially in the north of Scotland, where a wholesale destruction of trees took place. In the Tongue district of Sutherland about 1800 trees were blown down, while in the Dunrobin district it is estimated that more than 50,000 shared the same fate.

DECEMBER 22, 1894, 8 A.M.—*Gale in which the Highest Mean Hourly Velocity of the Wind was recorded* (Fig. 25).—This was a gale of quite an ordinary type, but of unusual severity. The centre of the storm passed rapidly eastwards across the north of Scotland on the night of December 21, and afterwards travelled across the North Sea, and on to the Baltic and Russia. On the morning of the

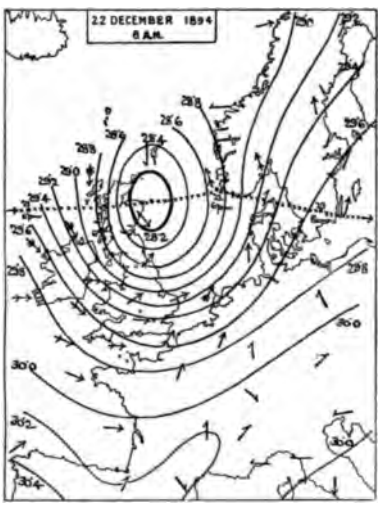

FIG. 25.

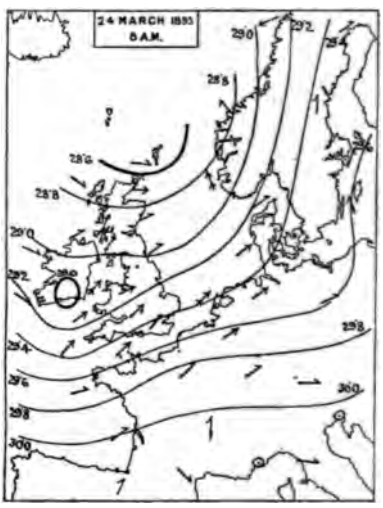

FIG. 26.

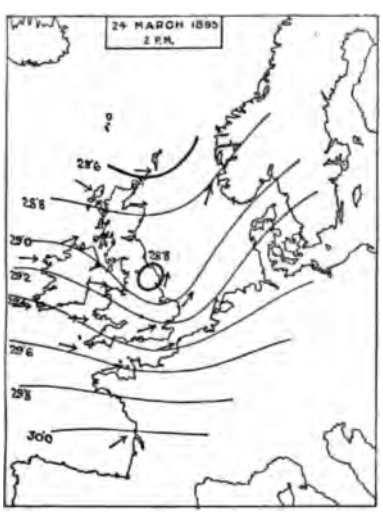

FIG. 27.

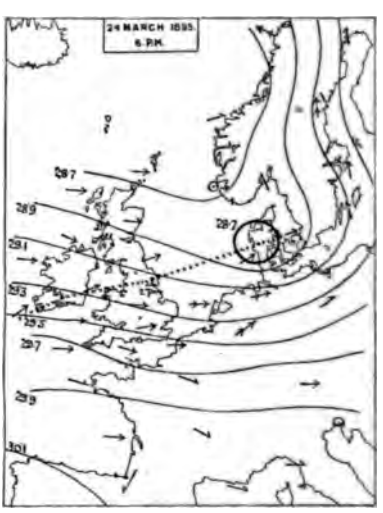

FIG. 28.

22nd the barometric gradient was very steep over the whole kingdom, and especially over the north of England, where it amounted to as much as 0·6 inch per 100 geographical miles. At 9 a.m. the mean hourly velocity of the Westerly wind at Fleetwood was as high as 107 miles (nominal) or 78 miles (true), this being the highest on record. Unusually high velocities were registered also at Deerness (61 miles at 11 a.m., from North-north-west) and at Alnwick Castle (58 miles at 6 a.m., from South). At Holyhead the mean hourly velocity

during this gale did not exceed 52 miles. The storm resulted in a large amount of damage on land and great loss of life at sea; during its progress sea salt was borne on the wind to great distances inland, even as far as to Birmingham (55 miles from the nearest coast) and to Masham in Yorkshire (65 miles inland). (A discussion of this storm by Mr. Charles Harding will be found in the *Quarterly Journal Royal Meteorological Society*, vol. xxi. p. 92.)

MARCH 24, 1895.—*The Swiftest-moving Storm System of the 30 Years* (Figs. 26-28).—This gale, though treated with cold neglect by the investigators of our Society, was in some respects one of the most remarkable of the whole period. It was due to the rapid movement across our islands of a small but deep secondary cyclone, the primary being situated off our northern coasts. At 8 a.m. on the 24th the centre of the secondary was situated over the south-east of Ireland, but by 2 p.m. it had reached the neighbourhood of Whitby, while by 6 p.m. it was over the north of Denmark, its average rate of travel across our islands and the North Sea being about 62 geographical miles per hour, the highest on record. Throughout its progress the steepest barometric gradients were found a short distance to the southward of the storm centre, and although pressure at the time was high over France, the English Channel escaped with nothing more than strong winds. Over the Bristol Channel, Wales, and the central parts of England, however, a gale of short duration but of unusual severity prevailed; and over our midland and eastern counties an immense amount of damage was done both to trees and to structures of all kinds. A correspondent writing from Norwich to *Symon's Meteorological Magazine* stated that he well remembered the gale of October 14, 1881, but that the number of trees then blown down in that district was not to be compared with those destroyed by the gale of March 1895. Very few of our anemometer stations were within the area of greatest disturbance, but at Yarmouth, where the exposure to the westward is far from perfect, the wind blew from West at 4 p.m. with a mean hourly velocity of 50 miles.

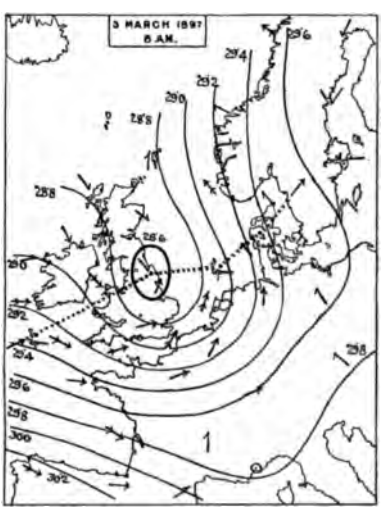

FIG. 29.

MARCH 3, 1897, 8 A.M.—*Gale with a High Wind Velocity in Squalls* (Fig 29).—This gale, like the last, was due to the passage of a small secondary cyclone over Wales and the north of England. The storm was felt in most of our Western and Southern districts, and was severe in the south of England, in which locality the barometrical gradient on the morning and afternoon of the 3rd amounted to about 0·35 inch per 100 miles. The greatest mean hourly velocity of the wind recorded was at Scilly, where 65 miles was registered at 6 a.m. on the 3rd. At the Rousdon Observatory a squall of the velocity of 101 miles per hour was registered by the Dines Pressure-Tube Anemometer at about 8.45 a.m., this being, so far as I am aware, the highest velocity recorded in these islands by an instrument of that kind. The gale occasioned a considerable amount of structural and other damage in many parts of our Southern counties.

AUGUST 3, 1900, 6 P.M.—*A Severe Summer Gale* (Fig. 30).—This gale was of unusual severity for the time of year. It occurred during the progress of

a storm system, the centre of which advanced over the St. George's Channel on the night of August 2, and which moved firstly in an easterly direction across England and the North Sea, and afterwards in a northerly direction over Denmark and Norway. At 6 p.m. on the 3rd the barometrical gradient over the western and central parts of England amounted to 0·35 inch per 100 miles. The strongest winds occurred in the rear of the disturbance, when force 10 from North-west or North was recorded on several parts of the English and Irish coasts. The highest mean hourly velocity registered was 50 miles at Fleetwood, but a velocity of 45 miles was registered at Kingstown, and 44 miles at Holyhead. The storm was followed on August 6 by another of almost equal severity, the occurrence of two such gales early in August being quite exceptional.

FIG. 30.

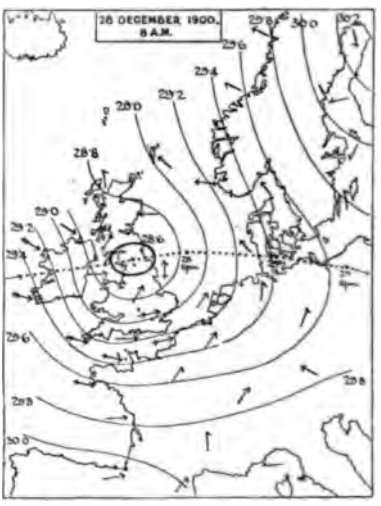

FIG. 31.

DECEMBER 28, 1900, 8 A.M.—*A Severe Winter Gale* (Fig. 31).—The close of the 30-year period was marked by a gale of unusual severity on all our western coasts. The storm was due to the passage across our islands of a cyclonic system of a very ordinary type, the centre advancing quickly over Ireland on the night of the 27th, and afterwards travelling more slowly across the north of England and the North Sea to Germany. The steepest gradient observed was one of 0·4 inch per 100 miles at 8 a.m. on the 28th, and over the northern and central parts of Ireland. The strongest winds were from the Westward or North-westward, force 10 to 11 being reported in most places, and force 12 by one or two of the lightship observers. At Kingstown the wind reached a mean hourly velocity of 55 miles, at Holyhead a velocity of 56 miles, at Valencia a velocity of 54 miles, and at Fleetwood a velocity of 64 miles, while at Scilly the velocity at 8 a.m., corrected by the factor 2·8, amounted to 70 miles. The gale resulted in much damage on land, and in numerous maritime casualties, with considerable loss of life.

Among all the severe gales of the 30-year period it would be very difficult to say which was entitled to rank as the worst, the degree of severity being in some cases so very similar. Of the general gales those of October 14, 1881, January 26-27, 1884, December 8-9, 1886, November 17, 1893, December 8, 1893, and December 22, 1894, seem

to hold about an equal place in the record of notability. Of those which affected the more southern districts only, the worst were, in all probability, those of December 8-9, 1872, March 12, 1876, and January 18, 1881. In the central portions of the country the gale of March 24, 1895, seems to have been unsurpassed for fury. In the north there were many notable gales, but among them we may select, by reason of its untimely appearance, the westerly storm of June 25, 1890, as worthy of mention. No storm of the 30-year period seems to have blown with anything like the severity of that which passed over England in November 1703, a detailed account of which was given at the time by the eminent writer De Foe.

The State of the Ice in the Arctic Seas, 1901.—A paper on this subject, which was read by V. Garde before the Seventh International Geographical Congress, has been printed by the Danish Meteorological Institute in the *Nautical Meteorological Annual*, 1901. The exertions of the Meteorological Institute to collect information about the drift-ice in the Arctic seas have met with a fair amount of support during 1901. Though not in possession of the full particulars, they still have very adequate information from the North Atlantic arctic seas and some information from the Behring Sea and Behring Strait. There is, however, an entire lack of information as regards the arctic sea north of Behring Strait.

The following is a summary of the results :—

The *Siberian Arctic Sea.*—The only information we possess as to the state of ice is, that the Toll-Expedition on board the *Sarja* passed Cape Tscheljuskin on September 1, 1901, or about ten days later in the year than the *Vega* and some ten days earlier in the year than the *Fram*. By the middle of September, lat. 77° 32′ N. was reached north of the New-Siberian Islands. On September 24 they put up their winter quarters in Herpinski Bay.

Kara Sea.—The western and eastern part have been very free of ice. From the north-eastern part no information has been received. The access to the Kara Sea from the west was very difficult, the Kara Strait only breaking up on August 2, the Jugor Strait at the beginning of September, Matotschkin Strait by the middle of August, while the passage north of Nowaja Zemlja was blocked all the year.

Barents Sea.—Conditions of ice almost normal. Bear Island, however, was ice-free exceptionally early.

Franz Joseph Land.—State of ice favourable on the south side, but difficult towards Nowaja Zemlja as well as towards Spitzbergen. All through August sailing vessels navigated along the south coast without any trouble.

Spitzbergen.—The west coast was ice-free all the summer. As early as the beginning of July the south-east coast was even free of ice right up to King Charles' Land. On the north and north-east coasts, however, the state of the ice was very troublesome all through the summer.

East Greenland.—The belt of pack-ice was more narrow than in a normal year, but the winter-ice remained uncommonly late frozen to the coast. At Angmagsalik the state of the ice was difficult, the ice lying close under the shore all the summer and only making the station navigable about a fortnight later than usual.

The *coasts of Iceland* were free of ice except in April and December, when the polar-ice was met at Cape North and off Melrakka.

Atlantic Ocean.—In April and May icebergs were observed on the Greenland route far more to the east than for many years (the $\frac{2}{4}\frac{6}{4}$ on lat. 57¾° N., long.

33¾° W.). On the America route the first icebergs of the year were met in March off Newfoundland; in June, July and August, crowds of icebergs were met between Belle Isle Strait and lat. 41° N. The southernmost icebergs were met by the middle of June on lat. 42°·5 N., and on July 5 on about lat. 41° N. As late as in November a few detached icebergs were met off St. John, Newfoundland.

Labrador and *Hudson Bay.*—The state of the ice seems to have been normal.

Davis Strait.—During the spring far less east-pack was observed along South-West Greenland than in a normal year. Quite contrary to the usual state of things the coast was free of ice from the middle of April till the end of June. All through July and August the state of the ice was about normal, and in September the coast was again free of ice.

Baffin Bay and *Lancaster Sound.*—Exceptionally much clear water in Lancaster Sound and to the east of it in July and part of August. In narrow sounds and bays, and especially along the east coast of Baffin Land and Cumberland Island, the winter-ice remained uncommonly late lying far out at sea.

In *Smith Sound* the condition of the ice seems to have been considerably more favourable than during the immediately preceding years.

In the *Behring Strait* no arctic drift-ice whatever was found this year, and the winter-ice in Behring Sea was of normal dimensions.

As far as the Atlantic arctic oceans are concerned, the above-mentioned state of ice may to a great extent be explained by the prevailing conditions of wind. Winds about West were predominant during the spring and summer of 1901 as well round Spitzbergen and Nowaja Zemlja as in the Northern Atlantic, in Davis Strait and Baffin Bay. Besides this, the weather was very stormy and rough, and the short arctic summer only made its appearance in a very few places.

About Spitzbergen and Nowaja Zemlja the continuous Westerly winds caused: (1) the drift of the ice towards the west and south-west to be greatly checked; (2) the south-east and east sides of the groups of islands mentioned to be cleared of pack; and (3) large accumulations of ice to take place on the north sides.

In the Northern Atlantic the cold water and icebergs of the Polar current were carried further to the east than during a long span of the preceding years, while a sudden cold wave rolled across Northern Europe in the beginning of June.

The considerably delayed arrival of the ice off the coast of south-west Greenland may also be explained by the continuous Westerly and North-westerly winds.

The fact that the winter-ice remained so persistently on the east coasts of East Greenland and Baffin Land might seem to be at variance with the above, but as on all coasts facing east the breaking up of the winter-ice is principally due to the swell caused by the North-easterly and Easterly winds, the late breaking up of the ice is just in accordance with the prevailing wind.

Setting apart all other concurrent and incalculable causes, the state of the ice in 1901 will most likely have a very unfavourable influence upon the state of the ice round Iceland and Greenland in 1902.

CLOUDS.

By Captain D. WILSON-BARKER, R.N.R., F.R.S.E., F.R.Met.Soc.

[A Lecture delivered to the Royal Meteorological Society, April 16, 1902.]

I HAVE this evening the honour of addressing you on that branch of meteorology which has been longest observed and studied, viz. Clouds, which owe their presence to laws of which we are possibly more ignorant than of any other governing our planet. In fact, the serious study of atmospheric phenomena is a comparatively modern scientific development. It has, however, although beset with difficulty, made some progress.

We live at the bottom of the atmosphere, of which the higher regions must be explored for information as to its conditions and operations. High mountain-tops, balloons, and kites are the bases from which investigations are now made with some satisfactory results. Our President is at present chairman of a Committee which hopes to conduct some special kite observations, resulting in valuable and interesting contributions to our knowledge.

The atmosphere is a compound mixture of oxygen and nitrogen gases in the general proportion of 21 parts of oxygen to 79 parts of nitrogen, with very small quantities of other substances of which "watery vapour" plays a most important part in the subject we are dealing with this evening. Dust and bacteria also exercise much influence on the optical and physiological conditions of the atmosphere. This mixture of oxygen and nitrogen appears with extraordinary uniformity in all parts of the world. We may note in passing that while oxygen is a common substance in earth and sea, nitrogen is comparatively rare. All the gaseous molecules composing the atmosphere move freely among one another.

The extreme height of the atmosphere has been inferred, from observation of meteors, to be about 500 miles, but it seems hardly likely that human beings will ever be able to penetrate farther than 7 miles, the altitude reached by Mr. Glaisher, the Father of the Society. The weight of the entire atmosphere is about 80 billions of tons.

Strangely enough, the scientific attention paid with such success to all other branches of atmospheric conditions has, comparatively speaking, neglected the clouds. I propose this evening to notice them at some little length.

The tradition of cloud lore has come to us from ancient times. We mentally associate it with Eastern shepherds of old tending their flocks and anxiously scanning the heavens for good or evil weather portents. Many old doggerels are extant, such as—

A red sky at night
  Is the shepherd's delight.
A red sky in the morning
  Is the shepherd's warning.

Many others may be found in that admirable book on *Weather Lore*, by Mr. Inwards.

In all that concerns the practical application of cloud observation to

the science of weather forecasting, we are but little ahead of those ancient shepherds. Our backwardness must no doubt be in part attributed to the impossibility of making cloud specimen collections, and the consequent difficulty in the formation of a simple practical classification of clouds analagous to what we find to hand when geology, zoology, or vegetable nature is the object of study. Cloud photography has, however, done much of late years to reduce this difficulty. If we cannot have actual specimens, we can get accurate representations of every form and variety of cloud, and from their study we learn that, in spite of their constantly varying aspects, there still exists in clouds a uniformity of nature sufficiently marked to guide us in the evolution of a simple but practical classification. Several classifications exist. The French naturalist Lamarck was probably the first to formulate one; but Luke Howard, a London merchant (Slide 1), introduced about the year 1802 the first practical classification, and it is still in use.

Since the late Rev. Clement Ley drew attention to the value of cloud observation in weather forecasting, some progress has been made, in different parts of the world, in the art of measuring cloud heights and in noting their formation and character. The result of these studies has been most satisfactory, but we cannot be said so far to have more than skimmed the surface of a deep and complex subject.

Clouds are formed by two causes: (1) the mixing of two masses of air of unequal temperatures. This is known as the "condensation" formation, and to it until quite recently all formation of clouds was attributed; and (2) through changes occurring in the atmosphere, where expansion and consequent loss of heat take place, causing condensation of moisture. This happens when a mass of air rises from the earth's surface into the higher regions of the atmosphere. As it rises, it expands because of reduction of pressure, and also because there is more space to fill; this expansion, supposing there be no addition of heat from external causes, brings about a cooling; so that a portion of the moisture in suspension in the air becomes condensed; this is the "adiabatic" cause. Now, with increasing height there is a corresponding fall in the temperature of the air, a natural fall of about 1° for every 300 feet of elevation, and a fall of 1°·6 from "adiabatic" causes. The reverse process takes place when, from whatever cause, air descends. We know then, that warm moist air rising in the atmosphere would cool down to condensation point, at which the moisture would become visible as cloud. The real process, however, is much complicated by horizontal and vertical air-currents which produce whirls and eddies. In dealing with cloud waves later on, we shall see how the appearance of clouds constantly denotes the presence of air-currents.

A simple primary classification is best arrived at by a twofold division of cloud types as follows:—

Stratus, or sheet clouds, and
Cumulus, or heap clouds.

The former may be roughly considered the cloud of a settled, and the latter of an unsettled state of the atmosphere.

The desirability of some such simple division is evident from the difficulty experienced by learners in distinguishing the many varieties included in ordinary classification. The universality of this difficulty has

led to the adoption of special nomenclatures in different countries, notwithstanding the existence of an International System.

I now propose to show you cloud pictures illustrating certain varieties of both main types. [These pictures were shown on the screen by lantern slides, and were too numerous for reproduction here.]

Of *Stratus*, or sheet cloud, we find the lowest cloud to be:

(1) *Fog*, or ground stratus, which is cloud resting on the surface of the earth (Slides 2, 3, and 4), (Fig. 1).

Fig. 1.—Fog.

(2) *Stratus*, the well-known anticyclonic cloud which sometimes, in high barometric areas, covers large surfaces of the earth in the form of a dark gray pall of cloud, relieved here and there by streaks of light, which occur parallel to the horizon. This cloud does not appear to be of great vertical thickness, although little light penetrates through it (Slide 5).

(3) *High Stratus.*—This cloud, known to us as the mackerel sky, is pre-eminently one of beautiful forms which vary greatly in altitude and in size of nubecules (Figs. 2 and 3). It appears from the low *cirro-cumulus* (Slide 6), at a height of 9000 feet, to the *cirro-macula* of Clement Ley, at an altitude of 23,000 feet or more (Slide 7). It assumes all sorts of fantastic and beautiful shapes, such as waves, wavelets, stipplings, and flecks. The lovely iridescent colouring seen sometimes near the sun is produced by this cloud. It constitutes a not uncommon phenomenon, although but seldom observed.

Slide 8 illustrates a fine cirro-cumulus effect.

Slide 9 a wave effect; both of these clouds were followed within twelve hours by severe gales.

Slide 10, wavelets; Slide 11, stipplings; Slide 12, flecks; and Slide 13, iridescent cloud. These beautiful effects are produced by currents of air moving over one another, the different angles of crossing causing different effects. The pictures of ripples in water will, to a certain extent, illustrate this.

Slide 14 shows a phenomenon well known to sailors, and called

FIG. 2.—Mackerel Sky.

FIG. 3.—High Stratus, Mackerel Sky.

"cats'-paws," where the wind just touches the water lightly in places and produces ripplings.

Slide 15. The same effect is produced by air-currents, the cloud waves taking the place of those in water.

(4) *Cirrus*, the highest form of cloud known, is the most valuable from the point of view of the weather forecaster (Fig. 4). It appears ordinarily, in the form of wisps and feathery pieces scattered over the sky, and is then of very little import (Slides 16, 17, and 18). But when this cloud forms on the horizon as from a radiant point, resembling the spokes of a wheel (Slide 19) it is distinctly a warning signal, and all its indications should be carefully noted. This cloud is composed of fine ice crystals. When it completely covers the sky it is known as *cirro-stratus*. Halos and other optical phenomena result from this cloud.

The formation of *Nimbus*, or rain cloud, is at present doubtful. I think it is probably caused by a downward thickening of the cirrus form.

FIG. 4.—Cirrus.

It is quite distinct from another cloud from which rain falls, and which we shall consider later on (Slide 20).

Scud would appear to be fragments of clouds torn away from the main bodies by high winds, and by them hurried across the sky (Slide 21).

We now come to the *Cumulus*, or heap type of cloud. These clouds are almost entirely due to the "adiabatic" cooling process. They are often characterised by great thickness. The ordinary cumulus cloud hardly rises to a greater altitude than 7000 feet; but many of the squall or pillar varieties tower sometimes to 40,000 feet or more, thus invading the higher regions of the atmosphere. Of varieties of *Cumulus* we have

(1) The ordinary fine weather variety, a soft cotton-woolly looking cloud of smooth outline, which clearly indicates fine weather (Slides 22 and 23).

(2) *Shower Cumulus*, from which rain falls; it closely resembles the ordinary variety, but its edges are more fleecy, and its general appearance more solid (Slide 24), (Fig. 5).

(3) *Squall Cumulus*, from which rain, hail, or snow may fall, with increase of wind force (Fig. 6). There are four sub-varieties of this cloud (*a*), accompanied by rain (Slide 25); (*b*), rain, thunder, and lightning (Slide

26) (a tornado, Sierra Leone); (*c*), hail, thunder, and lightning (Slide 27),

FIG. 5.—Shower Cumulus.

FIG. 6.—Squall Cumulus.

in which the colour of the cloud is very distinctive; (*d*), snow (Slide 28). The characteristic feature of this cloud is a bold outline, with a *cirriform*

fringe; it towers to great altitudes. The cirrus fringe (Slide 29) often covers the sky ahead of the main body of the cloud.

Two rarer forms of *Cumulus* are *Pillar Cumulus* (Slide 30), a cloud which is found in the calm belts of the ocean, and is distinguished by a slender form rising to great altitudes; and *Roll Cumulus* (Slide 31), generally accompanies stormy winds, more especially polar West winds in the rear of a storm. Its appearance suggests the rapid rolling of a cloud across the sky. A still rarer form is illustrated by Slide 32. This appears in the form of scattered cloudlets over the sky. It indicates an electrical state of the atmosphere.

FIG. 7.—High Stratus and Cumulus.

These two pictures (Slides 33 and 34) show respectively a horizontal and vertical view of cumulus cloud which developed showers later on in the day.

It sometimes happens that two different types of cloud are visible simultaneously. This combination has, in one case, been regarded as a single cloud and named as such, but the unified appearance is only an effect of perspective. We find it in Slide 35, where a streak of stratus is seen stretched across a large *Cumulus* cloud. Slides 36, 37, and 38 also illustrate two types visible at the same time (Fig. 7).

In taking cloud observations it is desirable that note should be made of their comparative altitudes and velocity of motion.

It may be well to describe here the passage of a storm as it might present itself to a spectator in London, supposing there were no smoke to interfere with his observations.

The weather is fine, the sky cloudless; by and by *cirrus* threads appear on, or parallel to, the south-west horizon moving from a point about north-west; gradually the sky becomes covered with threads of *cirrus* which increase in extent until they reach right across the sky from north-west to south-east, presenting the appearance of Slide 39 at either of these points. As the sky thickens, halos appear (Slide 40), only however to disappear as the thickness grows greater; the sun now shines faintly through a watery-looking mass of cloud, rain comes on, the wind freshens and blows up in gusts from an equatorial west point (Slide 41), and soon increases to a gale. Some hours later a break will appear in the sky to the north-west (Slide 42), the wind shifts to that quarter, the cloud passes away, rain ceases, and the blue sky becomes visible. As the

Fig. 8.—Halo.

cloud edge passes over the observer, the *cirriform* top is seen (Slides 43, 44, and 45), and a polar west wind accompanied by squalls is probable.

The next five slides show various clouds (Slides 46-50).

In connection with clouds we find many optical phenomena due to the diffraction or breaking up of the white light as it passes through the cloud particles. The most noticeable of these phenomena are *coronæ and halos. Coronæ* are concentric prismatic rings appearing close round the sun or moon. When round the sun they are seldom visible, as they are dimmed by the more brilliant light, but when seen in connection with the moon their full beauty is apparent. The colour red appears at the outer edge of coronæ.

Halos are larger prismatic rings of a diameter of 42°. They are plainly visible when round either sun or moon. They are red on the inner edge. Halos are due to the shining of light through the fine ice crystals of the very high *stratus* clouds of the *cirrus* variety (Fig. 8). When the *cirrus haze* is very fine and high, a *number* of rings may be produced; the picture (Slide 51) illustrates a set I saw in Sussex on a bright frosty morning in January 1900, when mock suns were also visible

(Slide 52). Many of these optical phenomena are extremely complicated and beautiful, but they are seldom seen.

Then there is the phenomenon of the sun pillar about which we have heard so much lately. It is a streak of white light extending perpendicularly some distance from the position of the sun, and, generally, just at sunset (Slide 53).

Other phenomena are the *auroræ* with which *cirrus* clouds seem intimately connected, and the appearance here shown, which is from a sketch I made of an auroræ australis, points in this direction (Slide 54). Then also there are the wonderful pink rays seen sometimes in the east when the sun sets, and in the west when the sun rises.

Slides 55 and 56 illustrate cloud shadows, and Slide 57 a rainbow.

The *blue* of the sky itself is worthy some attention. Its hues as we know are ever varying from the palest to the deepest blue. These changes are no doubt due to the presence or absence of cloud particles, too fine to be themselves visible.

This has been a very slight survey of an interesting subject, one in which it is possible to attain a fair amount of proficiency without very deep study (Slide 58).

We must have recourse to the physicist when we would work out the more intricate problems of a subject, upon the accurate knowledge and correct interpretation of which alone a true and useful system of cloud classification and system of observation can be founded.

[The blocks illustrating this Lecture have been kindly lent by the Editor of *Knowledge*.]

Lightning Photographs.—The following note appeared in a recent issue of *Photography*:—It has long been known that what appears to the eye as a single flash of lightning is in reality, in many cases, not one, or even two, but sometimes a whole series of flashes following the same or parallel paths. We note in our contemporary, the *Electrician*, some further comment on this subject by Herr Walter. Professor Kayser obtained photographs of lightning which showed a double flash some twenty or more years ago. In this case a strong wind blew aside the original path of the flash, so that the two did not fall upon exactly the same spot on the plate. Some twelve or thirteen years ago Weber got photographs of a very similar character by the simple expedient of moving the camera about. Herr Walter has improved upon this with a view to obtain a correct idea of the interval of time which separates the successive flashes. He mounts the camera upon an inclined axis, and gives it a rotary motion of a known and definite period, so that motion to a certain extent on the plate indicates the time that lapses between each flash. In one of the photographs he has so obtained the entire duration of the flash was ·15 of a second, from which it will be seen that the expression "as quick as a flash of lightning" might bear revision. This particular discharge consisted of three separate flashes with intervals between them of ·41 and ·11 second respectively. Only the first of these flashes shows any branches, due, it is suggested, to the pilot discharges. It will be noted that the question of the oscillatory or intermittent character of lightning flashes is one which still remains open.

Formation of Cloud.—Mr. J. Eliot in the *Indian Meteorological Memoirs*, vol. xii., part 2, supplies the following brief summary of the chief meteorological actions which give rise to the formation of cloud :—(1) Local ascensional movement. All ascending masses of air cool by the loss of their internal energy in the performance of the work of expansion. If the air masses ascend so high that the temperature by cooling falls below the dew-point, condensation will commence and give rise to cloud formation. The local ascensional movement may be due to various causes, of which the most important are as follows :—(*a*) The convective movements which occur during the day hours due to the irregular heating of the earth's surface and the superjacent lower strata of the atmosphere by the sun's thermal action. These movements usually give rise to the formation of clouds of the *cumulus* type. This action has a well-marked diurnal variation, commencing about 9 or 10 a.m., and reaching its maximum about 3 or 4 p.m. and ceasing about 6 p.m. (*b*) The ascensional or convective movement which occurs over the central areas of cyclonic storms and in all disturbances giving more or less general rain. (*c*) The ascensional movement of air across hills which lie athwart the general drift of a massive humid air current. Such currents may be either periodic or non-periodic, or irregular. The south-west monsoon currents, and the sea breezes on the Bombay, Arakan, and other coasts are examples of periodic currents.

This forced ascent of the air masses due to this action gives rise to clouds chiefly of the *cumulus* type. If the strength of this movement has a diurnal variation the accompanying cloud formation will have a similar variation. This is undoubtedly the case to a slight extent in the South-west Monsoon drift across the West Ghats and perhaps across the Arakan hills.

(2) Expansional movement on the large scale. There is no doubt that an important part of the diurnal atmospheric movement in India is due to the alternate expansion and contraction of the lower strata arising from their diurnal heating and cooling by contact with the earth's surface and other similar actions. This action is alternating and hence periodic. The character of the movement is partially indicated by the diurnal oscillation of the barometer. It is however, doubtful whether, except under exceptional circumstances of an almost saturated atmosphere, it gives rise to cloud formation on the large scale. Whenever it does so, the effect will probably occur chiefly about the epoch of the afternoon minimum of the diurnal pressure oscillation. This action occasionally gives rise to clouds of the *stratus* type.

(3) The action of atmospheric waves. These waves are formed at the common surface boundary of adjacent air currents of different temperatures, and moving with different velocities or in different directions. When one of the air currents is nearly saturated, condensation may occur, as shown by Helmholtz and others, in and near the common surface, in amounts depending upon the humidity of either wave. All clouds which have an undulating form of the lower surface, or clouds which are arranged in long lines or belts with intervals of clear sky are probably due to this action.

(4) The mixture of air masses of different temperature and humidity. This is most effective when cool dry air is injected into hot damp air (*vide* Cleveland Abbe's translation of von Bezold's three memoirs *On the Thermodynamics of the Atmosphere*).

(5) Cooling of nearly saturated masses of air (*a*) by radiation, (*b*) by conduction, (*c*) by diffusion, or (*d*) by motion from hotter to cooler regions.

It may be noted that these causes or actions operate in very different orders of frequency. The most usual causes of the formation of cloud in the dry weather in India are 1*a*, 1*b*, and 2, and to a less extent 1*c* and 3, and in the rains or wet season 1*b*, 1*c*, 2, and perhaps 4 in certain parts of India.

REPORT OF THE COUNCIL

FOR THE YEAR 1901.

IN presenting their Report the Council desire to congratulate the Society on the steady increase in the number of Fellows. The Council have, however, to deplore the loss of two of their own number by death, viz. Sir Cuthbert Edgar Peek, Bart., one of the Vice-Presidents, and Major Lamorock Flower. The loss of Sir C. E. Peek, at a comparatively early age, is felt the more keenly on account of the very valuable work that he was carrying on at Rousdon, Devon.

Committees.—The Council have been materially assisted by several Committees during the year, which were constituted as follows:—

EDITING COMMITTEE.—Messrs. F. C. Bayard, R. Bentley, R. Inwards, and R. H. Scott.

GENERAL PURPOSES COMMITTEE. — The President, Secretaries, Treasurer, Messrs. R. Inwards, B. Latham, and H. R. Mill.

WIND FORCE COMMITTEE. — The President, Secretaries, Messrs. R. H. Curtis, C. Harding, Capt. M. W. C. Hepworth, Mr. R. Munro, (the late) Sir C. E. Peek, and Capt. D. Wilson-Barker.

KITE COMMITTEE.—The President, Secretaries, Messrs. H. R. Mill, H. S. Wallis, and Capt. D. Wilson-Barker.

Address to The King.—The Council and Fellows presented a loyal and dutiful Address of sympathy and condolence with His Majesty the King on the occasion of the demise of Her Majesty Queen Victoria, and a letter has been received from the Home Secretary conveying "His Majesty's thanks for the same."

Lecture.— A lecture on "Climate and the Effects of Climate," illustrated by numerous lantern slides, was delivered by Dr. H. R. Mill, at the request of the Council, in the lecture theatre of the Institution of Civil Engineers, on March 20, and was greatly appreciated by a large audience.

Lightning Research.—At the request of a Joint Committee on Lightning Research, organised by the Royal Institute of British Architects and the Surveyors' Institution, the Council nominated Mr. W. N. Shaw, F.R.S., as the delegate from this Society, to join the Committee, and they contributed the sum of £5 : 5s. as a donation towards the expenses of the enquiry.

Symons Memorial Medal.—At the Council Meeting on June 19 the following letter was read:—

To the President and Council of the Royal Meteorological Society.

GENTLEMEN—At the invitation of the President of the Royal Meteorological Society (Dr. C. Theodore Williams), a meeting was held on May 31, 1900, to consider the question of a Memorial to the late Mr. G. J. SYMONS, F.R.S., when it was unanimously resolved that the Memorial should take the form of a Gold Medal, to be awarded from time to time for distinguished work in connection with Meteorological Science.

This proposal has been generously supported, and the sum of £713 : 14 : 7 has been subscribed for the purpose.

It is very gratifying to learn how greatly Mr. Symons was esteemed and

his work appreciated, for the subscribers number 323, and the contributions have ranged from 25 guineas down to half-a-crown.

The designs for the dies for the Medal have been approved; the obverse being the head of Mr. Symons, and the reverse the Tower of the Winds at Athens. The execution of the work has been placed in the hands of Mr. J. Pinches.

At the final meeting of the subscribers, held on the 11th instant, it was resolved that £600 Cardiff Corporation Redeemable Stock, bearing interest at 3 per cent, be handed over to the Royal Meteorological Society, the interest on the same to be used for the award of future Medals; and that the balance of the Fund (after paying the expenses of printing and postage, and the cost of the dies) be also handed over, with the request that the Society will expend the same in awarding the first Medal, if possible, within two years of the death of Mr. Symons.

The subscribers request the Council of the Society to comply with the following conditions:—

1. That the Medal be awarded for distinguished work done in connection with Meteorological Science, irrespective of sex or nationality.
2. That the Medal be awarded biennially, unless the Council see fit to withhold the award.

We have the pleasure of enclosing the transfer to the Royal Meteorological Society of the £600 Cardiff Corporation Stock. The balance of the Fund, which will amount to about £32 : 3 : 4, and also the dies for the Medal, will be handed over to the Society later on.—We are, Gentlemen, yours faithfully,

C. THEODORE WILLIAMS, *Treasurer.*
RAPHAEL MELDOLA, } *Secretaries.*
WM. MARRIOTT, }

June 14, 1901.

The Council willingly accepted the transfer of the property, subject to the recommendations of the subscribers as to the award of the Medal.

The Council, at their meeting in October, adopted the following regulations respecting the Medal:—

1. The Symons Memorial Gold Medal shall be awarded, irrespective of sex or nationality, for distinguished work done in connection with Meteorological Science.

2. The Medal shall, subject to the regulations following, be awarded biennially, and shall be presented at the Annual General Meeting in January (the first presentation to take place in January 1902).

3. At the Regular Meeting of the Council in the month of October in alternate years the Council shall take into their consideration the awarding of the Medal. The name of every person who may be proposed and seconded as deserving the same shall be entered in the Minute-book. No person who is, or has been, a member of the Council since the last Annual General Meeting shall be eligible to receive the Medal.

4. In the event of more than one person being proposed in October the Council shall, at their Regular Meeting in November, select by ballot one of the persons so proposed. A detailed list of the qualifications of the person selected shall be entered in the Minute-book, and read at the Annual General Meeting.

5. The Medal shall not be awarded unless two-thirds at least of the members of the Council present shall agree thereto. In the event of the

requisite majority of votes not being obtained, the Medal shall not be awarded in that year.

6. In the event of no award being made at the time prescribed, it shall be in the power of the Council to make an award in the following year.

At their meeting on November 20 the Council designated Dr. Alexander Buchan, F.R.S., as the first recipient of the Medal.

Howard Medal.—The Howard Silver Medal to the Cadets of the National Training College H.M.S. *Worcester* was this year awarded to Cadet C. de V. Le Sueur, for the best essay on 'The Meteorology of the Antarctic Regions.'

Kite Committee.—This Committee was appointed for the purpose of considering the advisability of undertaking observations in the upper atmosphere by means of kites or otherwise, with power to co-operate with any other body. At the meeting of the British Association at Glasgow a similar Committee was appointed, with a grant of £75, for the purpose of co-operating with the Committee of this Society. The Council have made a grant of £25 from the Research Fund towards the expenses of this investigation, and they have much pleasure in stating that the President has offered to devote three months next summer [1902] to making the observations.

Meetings.—With the exception of those in May and June, which were held in the afternoon in the Society's rooms, the meetings of the Society were held as usual, by the courtesy of the President and Council of the Institution of Civil Engineers, at their house, Great George Street, Westminster.

Index to Quarterly Journal.—The Council have published an Index to the *Quarterly Journal*, vols. viii. to xxvi., comprising the years 1882 to 1900, in continuation of the previous Index.[1] They trust that this Index will prove a boon to the Fellows, and will enhance the value of the Society's publications.

Quarterly Journal.—Amongst the papers of interest and value published in the *Quarterly Journal* during the year was the Presidential Address by Dr. C. Theodore Williams on 'The Climate of Norway and its Factors'; 'On the Variations of the Climate of the Geological and Historical Past, and their Causes,' by Dr. Nils Ekholm, Hon. Member; 'An Account of the Bequest of G. J. Symons, F.R.S., to the Royal Meteorological Society,' by Mr. William Marriott; and 'The Seismograph as a Sensitive Barometer,' by Mr. F. Napier Denison.

Meteorological Record.—Five parts have been issued during the year, bringing this publication to March 1901.

Wind Force Experiments.—These experiments have now ceased, and the Committee hope shortly to report.

Stations.—Observations have been discontinued at the following stations: Aspley Guise, Killarney, and Londonderry. Observations have been accepted from the following new stations: Enniskillen and Salcombe.

Inspection of Stations.—All the stations south of 54° N. lat. and west of 2° W. long., as well as such other stations as could be conveniently

[1] *Index to the Publications of the English Meteorological Societies*, 1839 *to* 1881.

visited, were inspected, and found to be on the whole in a satisfactory condition. Mr. Marriott's Report thereon will be found in Appendix II. p. 178.

Phenological Report.—This valuable Report was, as usual, prepared by Mr. Mawley, and read at the February meeting. The Society owes its best thanks to Mr. Mawley for his persevering labours in its preparation.

Library.—The rearrangment of the Library, consequent on the removal to the present rooms and the magnificent bequest of the late G. J. Symons, has been a work of great difficulty, and is not yet finished. The Council have directed that the Card Catalogue shall be prepared in duplicate, with the intention of forming a catalogue of subjects in addition to the alphabetical list under the authors' names.

Fellows.—The changes in the number of Fellows are given in the following Table, which shows an increase of twenty-eight during the year :—

Fellows.	Annual.	Life.	Honorary.	Total.
1900, December 31	456	144	20	620
Since elected . . .	+61	+6	...	+67
Reinstated	+ 1	...	...	+ 1
Deceased	−19	−2	−1	−22
Retired	−17	...	...	−17
Struck off	− 3	...	...	− 3
1901, December 31	479	148	19	646

Deaths.—The Council have to announce with much regret the deaths of one Honorary Member and nineteen Fellows, viz. :—

Benjamin Barrow, F.R.C.S., J.P.	elected	Mar.	2, 1852.
Rev. Joseph Chadwick Bates, M.A., F.R.A.S., F.G.S.	,,	Mar.	18, 1863.
Rev. John Archibald Legh Campbell, M.A.	,,	Feb.	20, 1878.
Rear-Admiral João Carlos De Brito Capello (Hon. Mem.)	,,	Dec.	20, 1882.
James Conroy	,,	Nov.	17, 1875.
William Santo Crimp, M.Inst.C.E.	,,	Mar.	19, 1890.
Frederick Hussey Daniel Eyre	,,	June	15, 1881.
Major Lamorock Flower	,,	Dec.	19, 1894.
Sir Joseph Henry Gilbert, Ph.D., LL.D., F.R.S., F.C.S.	,,	Nov.	16, 1870.
Major John Macpherson Grant	,,	Nov.	20, 1895.
Ralph Heap, M.A., F.R.G.S.	,,	Nov.	20, 1889.
Leonard Clements Henry, F.R.G.S.	,,	Feb.	20, 1901.
Thomas Thomas Marks, Assoc.M.Inst.C.E.	,,	Apr.	19, 1882.
Arthur William Martin	,,	June	16, 1880.

Charles Meldrum, M.A., LL.D., C.M.G., F.R.S., F.R.A.S.	elected	Apr.	15, 1868.
James Nicol, M.D., J.P.	,,	Feb.	19, 1873.
Miss Eleanor A. Ormerod, LL.D.	,,	Feb.	20, 1878.
Sir Cuthbert Edgar Peek, Bt., M.A., J.P., F.R.G.S.	,,	June	16, 1880.
James Edward Prichard, B.A., M.B., M.R.C.S.	,,	Mar.	16, 1898.
Frederick Pattison Pullar, F.R.G.S.	,,	Mar.	16, 1898.
Basil Woodd Smith, J.P., F.R.A.S.	,,	Mar.	19, 1862.
Harold Smith	,,	June	15, 1881.

Sound Signals and Weather.—In a paper on "Sound Signals" recently read before the Society of Arts, Mr. E. Price Edwards refers to some interesting experiences in connection with the propagation of sound signals through the atmosphere. He says that "there can be no doubt that as fog of no great density will obscure the most powerful light, so an opposing wind of a certain strength will infallibly quench, at a very short distance, the most powerful sound that can be produced. I have cited an instance of the disc siren having on occasion being heard for 20¼ miles. This was in calm, clear weather, with a smooth sea. On another occasion, with a wind of force 3 to 4 blowing against the sound, the same instrument, operated under similar conditions as when it was carried to so great a distance, could not be heard beyond 1¼ mile. It seems almost incredible that so slight a force of opposing wind should have such an effect, but the fact remains. It must also be borne in mind that, with any wind, the sea surface becomes disturbed; and in addition to the actual effect of the wind in obstructing the passage of the sound waves, the continued noise of the splashing sea waves, and their dash against the sides of the ship, the noisy movements of the vessel herself, and additional local sounds on board caused by her unsteady movements, take possession of the ears, and tend to prevent sounds, already attenuated by coming from a distance, from being clearly apprehended. It is of importance to take note of the fact that a sound heard on one occasion for 20 miles may, under different conditions, be heard only 1¼ mile; and it shows clearly that it is of no use to quote the experience of one day as an indication of what may always be expected. People unacquainted with the capricious action of the weather on sound transmission are very apt to speak with undue confidence, and make positive and misleading assertions regarding the performance of sound signals from one or two experiences of them.

"Fortunately, when fog prevails the atmosphere is, as I have before observed, as a general rule undisturbed, and the sea surface quiescent. Moreover, at such time the air is usually in a more homogeneous condition both as regards temperature and density, and aqueous vapour is uniformly distributed throughout the area affected. Under these conditions the sound waves pass without meeting the obstruction which it may be assumed they encounter when the air is agitated or intersected with currents of varying temperature or vapour saturation. It so happened that no fog was experienced during the recent trials, but the results obtained in the experiments of 1874, as recorded by Professor Tyndall, entirely supported the views above expressed. With this knowledge in our possession it may fairly be argued that the favourable results obtained in the trials at St. Catherine's in clear weather would have been fully borne out and possibly surpassed in foggy weather. I do not, of course, assert that fog is never accompanied by wind or a noisy sea, but such a condition of things is very exceptional, and wind generally has the effect of dispersing fog."

APPENDIX

STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.

Balance from 1900			£46 2 5
Subscriptions for 1901	£810 0 0		
Do. for former years	93 0 0		
Do. paid in advance	42 0 0		
Life Compositions	126 0 0		
Entrance Fees	61 0 0		
		1132 0 0	
Meteorological Office—Copies of Returns	£106 15 2		
Do. Grant towards Inspection Expenses	25 0 0		
		131 15 2	
Dividend on Stock (including £47 : 15 : 7 from the New Premises Fund)	133 0 4		
Income Tax returned (3 years)	16 3 3		
		149 3 7	
Sale of Publications, &c.		56 7 2	
		£1515 8 4	

I.

FOR THE YEAR ENDING DECEMBER 31, 1901.

EXPENDITURE.

Journal, &c.—					
Quarterly Journal, Nos. 117 to 120	£153	3	9		
Illustrations	24	12	8		
Authors' Copies	13	14	6		
Meteorological Record, Nos. 77 to 81	82	7	0		
Reprints from Registrar-General's Reports	2	9	2		
				£276	7 1
Printing, &c.—					
General Printing	£28	1	6		
Index to Quarterly Journal	26	12	6		
Stationery	23	10	0		
Books and Bookbinding	38	18	7		
				117	2 7
Office Expenses—					
Salaries	£552	19	6		
Rent and Housekeeper	200	0	0		
Coals, Lighting, and Insurance	14	18	6		
Repairs, &c.	3	16	7		
Postage	70	18	3		
Petty Expenses	20	5	0		
Refreshments at Meetings	17	2	1		
Illuminated Addresses to the King, and Dr. Williams	5	3	0		
				885	2 11
Observations—					
Inspection of Stations	£58	5	9		
Observers	11	4	0		
Instruments	16	2	1		
Donation to the Lightning Research Committee	5	5	0		
				90	16 10
				£1369	9 5
Balance—					
At Bank	£128	17	10		
In hands of the Assistant-Secretary	17	1	1		
				145	18 11
				£1515	8 4

Examined, compared with vouchers and found correct,

FRANCIS DRUCE,
T. P. NEWMAN, } *Auditors.*

January 8, 1902.

APPENDIX

ASSETS AND LIABILITIES

LIABILITIES.

To Subscriptions paid in advance	£42 0 0		
,, Rent for quarter ending December 25, 1901 . . .	50 0 0		
		£92 0 0	
,, Excess[1] of Assets over Liabilities		3624 9 8	
		£3716 9 8	

[1] This excess is exclusive of the value of the Library, the Stock of Publications, and the Symons Bibliography and Bequest.

WM. MARRIOTT, *Assistant-Secretary.*

NEW PREMISES FUND,

Amount paid to the Society's Fund towards the rent of rooms at 70 Victoria Street	£47 15 7

RESEARCH FUND,

Amount invested in the purchase of £3 : 4 : 9, 2¾ per cent Consols . .	£3 1 0

SYMONS MEMORIAL

Contributions received during 1900 and 1901	£713 14 7
Interest received on Investment, 1901	17 0 6
	£730 15 1

'.—Continued.

)N JANUARY 1, 1902.

ASSETS.

}y Investment in Great Central Railway 4½ per cent Debenture Stock, £800 at 131½ xd	£1052 0 0		
,, Investment in New South Wales 4 per cent Inscribed Stock, £654 : 18s. at 115½	756 8 3		
,, Investment in London & North-Western Railway Consolidated Stock, £400 at 168	672 0 0		
,, Investment in 2½ per cent Annuities, £231 : 11 : 9 at 93⅞	217 18 1		
		£2698	6 4
,, Subscriptions unpaid and recoverable, estimated at	£60 0 0		
,, Entrance Fees unpaid and recoverable, estimated at	10 0 0		
,, Interest due on Stock	54 8 7		
,, Meteorological Office—Weekly Returns, 1901	27 19 1		
		152	7 8
,, Furniture, Fittings, &c.	£575 2 9		
,, Instruments	144 14 0		
		719	16 9
,, Cash at Bank of England	£128 17 10		
,, Cash in hands of the Assistant-Secretary	17 1 1		
		145	18 11
		£3716	9 8

Examined, and securities seen at the Bank of England,

January 8, 1902. FRANCIS DRUCE, T. P. NEWMAN, } *Auditors.*

)ECEMBER 31, 1901.

nterest received on Investment	£47 15 7

Note.—The Society holds on account of this Fund £1443 : 7 : 9 South Australian 3½ per ent Inscribed Stock.

Examined, and certificate seen at the Bank of England,

January 8, 1902. FRANCIS DRUCE, T. P. NEWMAN, } *Auditors.*

)ECEMBER 31, 1901.

nterest received on Investment	£3 1 0

Note.—The Society holds on account of this Fund £114 : 4 : 9, 2¾ per cent Consols.

Examined,

January 8, 1902. FRANCIS DRUCE, T. P. NEWMAN, } *Auditors.*

MEDAL FUND.

'urchase of £600 Cardiff Corporation 3 per cent Stock at 98¼		£589	11 0
)ies for Medal		65	0 0
'rinting and Postage		35	11 3
		£690	2 3
Balance—At Bank	£37 9 11		
,, In hands of the Assistant-Secretary	3 2 11		
		40	12 10
		£730	15 1

We have seen at the Bank of England certificate for the above-mentioned Stock, and there is a balance at the Bank of England in favour of the Fund of £37 : 9 : 11, and in the hands of the Assistant-Secretary of £3 : 2 : 11.

January 8, 1902. FRANCIS DRUCE, T. P. NEWMAN, } *Auditors.*

APPENDIX II.

INSPECTION OF STATIONS, 1901.

All the stations in the south-west and west of England and Wales, as well as those in Ireland, have been visited, and were found to be generally in a satisfactory condition.

The number of thermometers which have been tested has been 201, in no less than 53 of which there has been an alteration of zero.

As mentioned in my last Report, the site for the instruments at Scarborough was not a happy one, as it was too near a sloping bank. This bank, which faces west, is exposed to the afternoon sun, and consequently becomes greatly heated. It retains this heat for a considerable time, and so affects the evening temperatures. As a matter of fact, we have found that the temperatures at 9 p.m. are considerably higher than those formerly registered in Scarborough. The difference in the summer amounts to fully 4°. When visiting this station this year I pointed out to the Chairman of the Meteorological Sub-committee at Scarborough the desirability of having another set of instruments placed in some other part of the town, so that comparative observations might be made between them and those at the present site. I am glad to say that the Borough Surveyor has undertaken to carry out these new observations.

At Weston-super-Mare the local authorities have recently complied with my request to place a fresh set of instruments in the Emmanuel churchyard, in order to bring the station within the requirements of the Society.

The number of photographs taken at the various stations has been 42. These, together with those of previous years, form an interesting collection of facts relating to the exposure and surroundings at the various stations of the Society. WM. MARRIOTT.

October 16, 1901.

NOTES ON THE STATIONS.

ABERYSTWITH, *July* 15.—There was no change in the thermometers. The rain-gauge in the enclosure at the Castle grounds is too confined. Dr. Thomas has a second rain-gauge in his garden at North Parade, which has a good exposure. There are now two Jordan sunshine recorders; the new one being placed on the tower of the old Castle. It was put there because the tower itself cut off some of the morning sun from the other recorder. Neither of the recorders was in proper adjustment; the old one being set for latitude 46° and was 10 minutes fast, while the new one was set for latitude 47° and was 25 minutes fast.

ARDGILLAN, *July* 19.—The instruments were clean, and the station was in good order. I recommended a rearrangement of the thermometers in the screen. Capt. Taylor has a very full equipment of thermometers, and duplicates of most of them. The station, which is surrounded by numerous trees, is about 800 yards from the sea.

ASHBURTON, *August* 23.—At the time of my visit the thermometers were hung under a tree, the screen having been taken down for painting. I recommended that the thermometer screen be removed to the site near the rain-gauge, so as to have a more open exposure, and be free from the influence of the bank at the present site. The wet bulb was not working properly, the muslin being nearly dry. On comparing the thermometers it was found that the wet bulb had gone up 0°·1, and the maximum 0°·4.

BATH, *August* 12.—The 1-foot earth thermometer was let down into the soil through a glass tube. This had been broken a few days previous to my visit. I recommended that an iron tube of the Symons pattern be obtained. The muslin on the wet-bulb thermometer required changing. The trace of the sunshine recorder was not running parallel with the card. This was due to the instrument being out of adjustment for time. I recommended that the recorder be firmly clamped in proper position. A large theatre was being erected a short distance off, on the eastern side of the Guildhall. This will probably cut off a little of the early morning sunshine, as the roof makes an angle of nearly 6°.

BELMONT, *July* 11.—This station is at St. Michael's Priory, 2½ miles south-west of Hereford. The instruments were in good order. The grass minimum thermometer had some spirit up the tube. I gave the observer instructions as to the measurement of snow.

BUXTON, *July* 29.—The muslin on the wet-bulb thermometer was too thick, and required changing. I recommended a rearrangement of the thermometers in the screen, in order to get better light on the scales of the dry and wet bulbs. The posts of the thermometer screen were rotten, and required renewing; and the screen also needed painting. The observer's measurement of snow was unsatisfactory. I urged him always to melt and measure what was actually in the gauge. The barometer seemed to be in good adjustment, but I recommended that it be removed to Mr. Pilkington's house. The sunshine recorder had been tampered with on the day of my visit. The index hand for latitude had been broken off, so I adjusted the instrument by my altazimuth to 53°. Trees on the south-west and west subtend an angle of 10°. The observations seemed to be taken under difficulties, as the observer lives a considerable distance from the instruments.

CAHIR, *July* 18.—This station is about a quarter of a mile south of the railway station. The thermometer screen is placed at the north-east corner of the garden, and is somewhat hidden by trees from the public eye, but the exposure is good. The rain-gauge is in a very open situation. The Jordan sunshine recorder has a good exposure except for a tree in the west. The instrument required adjusting for time. It seemed desirable to have all the instruments together, so I selected a site in field which has an open exposure. I recommended a rearrangement of the thermometers in the screen. The grass minimum had some spirit up the tube.

CASTLE HILL, *August* 15.—The instruments were in good order. On comparing the thermometers it was found that the dry and wet bulbs had both gone up 0°·2.

CHELTENHAM, *August* 12.—This station is at the Modern School, in Prestbury Road. The country is level to the foot of the Cotswold Hills, about 2 miles to the east. On comparing the thermometers it was found that the wet bulb had gone up 0°·1, and the maximum 0°·3. I recommended that the position of the maximum and minimum thermometers in the screen be altered, in order to give a better view of the scales of the dry and wet bulbs. The rim of the funnel of the rain-gauge needed re-soldering.

CHESTER, *July* 26.—On comparing the thermometers it was found that the 1-foot earth had gone up 0°·3, the 3-feet 0°·6, the 4-feet 0°·1, and that the grass minimum had gone down 0°·4. The muslin on the wet bulb required changing.

CHURCHSTOKE, *July* 12.—This station is at Mellington Hall, nearly midway between Montgomery and Bishop's Castle. On comparing the thermometers it was found that the dry, wet, and minimum had all gone up 0°·2, and that the grass minimum had gone down 0°·2. The grass minimum had 0°·9 of spirit up the tube. The sunshine recorder is placed on the leaden roof of the staircase at the top of the tower. The observer says that he believes the lead gets heated by the sun, and so throws the recorder out of level. The frame was not level, the eastern side being 2½° lower than the western side. I packed it up level with cardboard. There was no sunshine at the time of my visit.

CULLOMPTON, *August* 24.—This station was in good order. On comparing the thermometers it was found that the wet bulb had gone up 0°·1. The sunshine recorder was in good order. The trees on the west and west-north-west may possibly intercept a little of the late evening sunshine.

DUBLIN, *July* 20.—This is in reality a "town" station, for the exposure is very confined. The instruments are placed in a small garden, the house on the east-south-east making an angle of 34°, and the stable on the west-north-west an angle of 31°. There are trees and shrubs in the gardens, which, however, are kept cut back, so as not to make a greater angle than the surrounding buildings. The thermometer screen is placed on a mound close to the garden wall facing north-north-west. The rain-gauge is placed on a mound in the centre of the garden. Under the circumstances possibly the temperatures may be higher than at a corresponding station in the open country. The observations, however, are carefully and regularly made.

ENNISKILLEN, *July* 22.—The instruments are placed on a grass plot in the kitchen garden of the Model School, which is only a short distance from the railway station. The exposure is very good, and the observations appear to be satisfactorily taken. I recommended a rearrangement of the thermometers in the screen. On comparing the thermometers it was found that the minimum had gone down 0°·5.

FALMOUTH, *August* 22.—This station was in good order. The minimum had 0°·8 of spirit up the tube. On comparing the thermometers it was found that both the dry and the wet bulb had gone up 0°·1.

GWERNYFED PARK, *July* 11.—The minimum had 1° of spirit up the tube. On comparing the thermometers it was found that both the dry and the wet bulb had gone up 0°·1. I recommended that more grass be laid down round the thermometers, so as to make a plot about 16 feet square. I also recommended that a grass minimum thermometer be obtained. The observer has occasionally reset the minimum during the day, and so lost the proper reading.

HAVERFORDWEST, *July* 16.—The instruments are placed in a terraced garden on the south side of the High Street. On comparing the thermometers it was found that the dry and the wet bulbs had both gone up 0°·1 and the maximum 0°·2. The muslin on the wet bulb required changing. The sunshine recorder is placed on the top of a closed reservoir, and has a perfectly open exposure. The instrument is of a Swiss make, and is smaller than the English pattern. The ball is 3¾ inches in diameter, and consequently the time-scale is different from the ordinary Campbell-Stokes. I recommended the observer to get the proper cards for the instrument, or to make a fresh time-scale, as he was using the cards for the ordinary English pattern.

HOYLAKE, *July* 27.—On comparing the thermometers it was found that the wet bulb had gone up 0°·1, and that the minimum and grass minimum had both gone down 0°·3. The exposure at this station is very good. There is a prospect, however, of some additional offices being erected on the east of the grass plot. If so, these will somewhat interfere with the exposure. The sunshine recorder has been placed on the top of the turret of the Council offices, and is now most fully exposed.

ILFRACOMBE, *August* 16.—There was no change in the thermometers. I recommended that buttons be placed under the minimum thermometer to prevent vibration, as the index appeared to creep up the tube when shaken.

ILTON, *August* 15.—This station was in good order. The tube of the minimum thermometer was rather loose, so I packed it up with cork. The Rev. E. B. Poole has a thermograph in the screen, which is a great check upon the readings of the other instruments.

KILLERTON, *August* 24.—I called to see the instruments at this station. The thermometers are not placed in a Stevenson screen, but are on the north side of a wooden frame painted black, with no projection or covering at the top. On the east and west sides of the frame are single louvred frames, so there is no protection from the weather, only from the sun. The rain-gauge is of the Crossley registering pattern. I suggested that a Stevenson screen and also a Snowdon rain-gauge be obtained and placed on the site which I selected. The exposure would then be good. The instruments are in Killerton Park, which is about 1 mile south of Silverton railway station, and 6 miles north-east of Exeter.

LLANBEDR, *July* 25.—The instruments at this station were in good order.

LLANDUDNO, *July* 26.—The instruments are placed on a grass plot at the corner of the garden adjoining the Royal Hotel. I recommended that ivy be permitted to grow on the wall, in order to check any possible reflected heat. The screen required strengthening to prevent vibration of the thermometers. I removed the barometer from the porch at Warwick House to the Council offices, the height of the cistern being 92 feet 8 inches above sea-level. The sunshine recorder is to be mounted on a new iron column.

LLANERCHYMEDD, *July* 24.—On comparing the thermometers it was found that the dry and wet bulbs had both gone up 0°·1, and that the minimum had gone down 0°·1. I recommended a rearrangement of the thermometers in the screen. Both Mr. Pritchard and his clerk were away at the time of my visit, but I saw the gardener who occasionally takes the readings. He seemed to read the instruments very well.

LONDONDERRY, *July* 23.—Mr. Conroy was seriously ill, so I did not see him. Owing to his illness no observations had been made for the past two months. This station is at Waterside, on the east bank of the river. The instruments are placed in a small garden with a confined exposure. The thermometer screen is a single louvred one. The rain-gauge has a shallow funnel, and a very large cylinder for receiver.

MALVERN, *August* 13.—On comparing the thermometers it was found that the dry bulb had gone up 0°·2, and the wet bulb 0°·1. The maximum, on Phillip's principle, had too long an index; and as it had got out of order previously, I advised that a new thermometer be obtained. I recommended that the position of the maximum and minimum in the screen be altered so as to give a better view of the scales of the dry and wet bulbs. On examining the rain-gauge I found some water in the receptacle, although there had been no rain since 9 a.m. The observer, apparently, had not emptied all the water out when he measured the rain in the morning.

NEWQUAY, *August* 21.—On comparing the thermometers it was found that the dry and wet bulbs had both gone up 0°·1. I altered the position of the thermometers in the screen to allow the cotton of the wet bulb to conduct more freely. At the time of my visit, two marquees had been put up close to the thermometer screen, for the purposes of a bazaar. The effect on the temperature, however, would be but slight. The rain-gauge was in its former position, but it will have to be moved when the new Wesleyan Chapel is built. The sunshine recorder is now placed on a brick pier on the top of the covered reservoir. It is about 3 feet higher than at the previous site.

NORTHWICH, *July* 29.—There was no change in the thermometers. I recommended that the maximum be mounted with more inclination, to prevent the mercury running up the tube. I gave the observer instruction as to estimating the amount of cloud, and also as to observing various phenomena.

PENZANCE, *August* 23.—On comparing the thermometers it was found that the dry and wet bulbs had both gone up 0°·1. The station was in good order. The Jordan sunshine recorder seemed to be about 5 minutes faster than the Campbell-Stokes.

PRINCETOWN, *August* 19.—The muslin on the wet bulb was dry, the cotton being too thin, and not working properly. I recommended that the screen be kept locked, in order to prevent any one interfering with the thermometers. As the screen needed repairing, and the posts were weak, I obtained the permission of the Governor of the Prison for a new screen to be put up with fresh legs. I gave the observer instructions as to the management of the wet-bulb thermometer.

RAVENSCAR, *July* 31.—I found that the observer had been reading the end of the spirit instead of the index in the minimum thermometer. I gave him instruction in the management of the wet bulb and also as to the measurement of snow. The instruments are well exposed and are close to the railway station.

RODEN, *July* 13.—On comparing the thermometers it was found that the wet bulb had gone up 0°·1, and that the minimum had gone down 0°·5. The condition of the wet bulb was not satisfactory, the bulb having a large piece of muslin round it and reaching into the water. A tin can was used for the water receptacle, but it was much too high, for it enveloped the bulb, and so prevented the proper circulation of air. I raised the thermometers and procured a glass receptacle with a cover to keep the water clean. The mercury in the maximum thermometer had a tendency to run up the tube when the screen was shaken. I therefore altered its position so that the bulb should be lower than the other end. I recommended that the curved pipe of the Glaisher rain-gauge should be made straight, and urged the observer to examine the gauge every day. I also recommended that more grass should be laid down under the thermometers. The amount of cloud was not correctly estimated. I explained how this should be done.

ROSS, *July* 10.—On comparing the thermometers it was found that the dry bulb had gone up 0°·1. The muslin on the wet bulb required changing. There was some water in the rain-gauge although there had been no rain that day. I urged upon the observer the desirability of examining the rain-gauge each morning.

ROUSDON, *August* 28.—This station was in good order. On comparing the thermometers it was found that the dry bulb and the 1-foot earth had both gone up 0°·1. It is the intention of Lady Peek to continue the Second Order observations.

RUMNEY, *August* 13.—The instruments were in good order. I gave the observer instruction in the management of the wet bulb during frost.

SALCOMBE, *August* 20.—The instruments were not in position at the time of my visit, so I selected what I considered to be the most suitable site. Salcombe is on the western side of the river, and the ground rises very steeply from the water. The instruments will be placed in the garden, on a small levelled piece of ground, and will have a south-east aspect. The height will be about 110 feet above sea-level. I gave the observer instruction in the reading of instruments, etc., and in the making up of the returns.

SCARBOROUGH, *July* 30.—The muslin and cotton on the wet-bulb thermometer were dry at the time of my visit. I instructed the observer to use better muslin and cotton. The sunshine recorder was not quite level. I called on the Borough Surveyor, and also on Dr. Hudson, the Chairman of the Meteorological Sub-committee, and asked them to arrange for a thermometer screen to be put up in some other part of the town, in order to ascertain what difference exists between it and the present site. There is no doubt that the slope to the west of the present site becomes much heated by the afternoon sun, and so raises the evening temperatures.

SHAFTESBURY, *August* 29.—The muslin on the wet-bulb thermometer required changing. The conducting thread was also too short. The mercury in the maximum thermometer appeared to have a tendency to run up the tube, and so to give too high a reading. I suggested that another maximum thermometer be placed in the screen, and the two read together. I recommended that a large bottle be placed in the rain-gauge cylinder.

SIDMOUTH, *August* 27.—This station was in good order. I recommended that the grass minimum thermometer be placed on the grass, near the rain-gauge. The sunshine recorder evidently loses a little of the early morning sun, owing to trees. There is also a tree on the west, the top branches of which I suggested should be cut off. Miss Radford has undertaken to continue the observations which have been carried on for so many years by the late Dr. W. T. Radford.

TORQUAY, *August* 26.—On comparing the thermometers, it was found that the maximum had gone down 0°·5, the minimum 0°·2, and the grass minimum 0°·9. The station was in good order. A second Campbell-Stokes recorder was placed on the pavilion, at the end of the pier. The exposure is very good, except for a flag-staff due south. It is contemplated to erect a new pavilion, and to place the sunshine recorder and the anemometer on it; or else to erect a column at the bend of the pier, and to place the sunshine recorder thereon. In either case, Vane Hill on the east by south will make an angle of 5°½, and the other hills on the east-north-east and east-south-east will make an angle of 4°. I met two members of the Pier Committee, and explained my views to them. The Chapel Hill thermometers and rain-gauge had been removed to an enclosure near the pier. These are not used for official purposes. I strongly urged that the Carey Green observations should be continued as the official ones. An ornamental hut has also been erected near the pier gates as an office, in which is placed the standard barometer. It is contemplated to place the barograph and thermograph outside this hut for public inspection.

WESTON-SUPER-MARE, *August* 14.—The Town Council had recently resolved to procure a new set of instruments, and to put them on the site which I selected last year. The plot in Emmanuel churchyard had been railed off, and the thermometer screen placed in position. I had the rain-gauge also placed in position. When complete, the station will comply with the requirements of the Society. The sunshine recorder was out of adjustment, the instrument

being set for latitude 40° instead of 51°. Mr. Perrett agreed to continue the observations on the roof of the Town Hall for some time, so that the two sets might run together.

WHITCHURCH, *August* 19.—This station is on the edge of Whitchurch Moor, 2½ miles south-east of Tavistock, and 5¼ west by south from Princetown. The instruments are placed in a kitchen-garden. The station was in good order.

WOOLACOMBE, *August* 16.—The instruments are placed in the grounds facing the Woolacombe Hotel. The exposure is very good. Hills extend from north-west through north and east to south, broken only by a valley to the east. The place is open to the sea, from south to north-west. On comparing the thermometers, it was found that the dry and the wet bulb had both gone up 0°·1. The barometer was not quite vertical, as the wall on which the board was fastened had settled somewhat. The funnel of the rain-gauge required re-soldering. I recommended that wooden buttons be put under the minimum thermometer, to prevent vibration in windy weather. The sunshine recorder was in good order.

APPENDIX III.

OBITUARY NOTICES.

BENJAMIN BARROW, F.R.C.S., J.P., died on March 7, 1901, at the age of 86, at St. John's Lodge, Ryde, Isle of Wight. We have no record of his early life, but Mr. Barrow settled in Ryde as early as 1848, and, being a man of great energy and enthusiasm, was not long in making his influence felt for the improvement of the town. In 1849 during the cholera epidemic he was most active, and took part in petitioning the General Board of Health to hold an inquiry at Ryde with the view of enforcing the adoption of the Public Health Act of 1848.

In 1852 he took an active part in promoting a scheme for a water supply from Alverstone, and this scheme being incorporated with others by a private Act of Parliament, Mr. Barrow was elected one of the first Commissioners and became Chairman of the Water Committee, of the Highways and Sanitary Committee, and of the Officers Committee.

Having retired from the Board of Commissioners in 1859, he, in 1866, offered his services as Honorary Medical Officer of Health to that body. These were accepted, and he performed the duties most efficiently until 1873.

Amongst other public works with which he was intimately connected was the construction of the Esplanades and the Boating Lake. He was elected nine times Mayor of Ryde, thus showing the public confidence in him from the municipal standpoint; and he was one of the founders of the Isle of Wight Literary and Philosophic Society in about 1850, which society, however, ceased to exist in the year 1875, when its Museum was handed over to the School of Art, of which Mr. Barrow was President until the year 1892.

He was a skilful surgeon, and was on the Hon. Medical Staff of the Isle of Wight Infirmary from its foundation. He was elected F.R.C.S., and was President of the British Medical Association when they met at

Ryde in 1881. It may be said that Mr. Barrow was actively associated with nearly all the public improvements for the town of Ryde from the time of his first residence there until his death.

He was elected a Fellow of this Society on March 2, 1852.

Rev. JOSEPH CHADWICK BATES was born on June 17, 1826, at Oldham. He was educated at Manchester Grammar School and Queen's College, Oxford. He was ordained by the Bishop of Manchester in 1850. From 1851 to 1856 he had a curacy at Hull, and for the last 43 years his life was closely interwoven with the history of the village of Castleton, of which he was vicar. His first interests were in the welfare of his church, schools, and the public affairs of his parish.

When he went to Castleton it was a small village, and he was appointed curate in charge of a small mission chapel by the Vicar of Rochdale. He soon started a movement towards building a church, and by 1862 St. Martin's Church had been built at a cost of £3000. During the 43 years Mr. Bates was Vicar of Castleton no less than £16,000 was raised for parochial objects. Mr. Bates took a deep interest in several branches of science, particularly astronomy, meteorology, and geology. He had a well-equipped meteorological station in the vicarage garden, and kept a careful record of the rainfall, temperature, etc. He was a Fellow of the Geological Society as well as of the Royal Astronomical Society. Mr. Bates possessed considerable mechanical skill, and constructed almost entirely with his own hand the dome over his equatorial. He built a room for his transit instrument himself, and he also carved parts of the stonework of the church.

Mr. Bates died on December 14, 1901, after a short illness.

He was elected a Fellow of this Society on March 18, 1863.

Rev. JOHN ARCHIBALD LEGH CAMPBELL was born in Edinburgh in 1824, and was the only son of the late John Archibald Campbell, Clerk to H.M. Signet. He seems to have been much in his father's society in his early years.

He received his early education at a private school at Duddingston, called Broughton's. From it he went to Oriel College, Oxford, where he graduated B.A. in 1847, and M.A. in 1852. After leaving Oxford he became a student in Wells Theological College. He was ordained deacon in 1848, and in due course priest, by the Bishop of Ely. From 1848 to 1855 he held the curacy of Elton, Huntingdonshire. In 1855 he was appointed Vicar of Helpston, Market Deeping. Here he ruled his people with a firm but beneficent hand.

It was while at Helpston that Mr. Campbell commenced his work in connection with the Training Colleges. He was appointed one of the Committee of Peterborough Training College, and so strongly did his ability and business capacities impress the other members of the Committee that they practically left the entire management of the College in his hands. In 1888 he resigned the living of Helpston, and retired to Scotland to spend the evening of his life.

It was in 1893 that Mr. Campbell was first appointed to the Committee of the Episcopal Training College. Of his work on behalf of the College it would be impossible to speak too highly. He was an

authority on ventilation, warming, and sanitation, and the improvements he introduced into the Training College were as great in these departments as were those brought about by his moral and intellectual qualities. He was always a welcome visitor both to the students and the members of the staff, and to none more so than the Principal, who placed the utmost reliance on his keen intellect, sound judgment, and practical, common-sense view of affairs. It is hardly too much to say that throughout the length and breadth of the Scottish Church, wherever there was a good work to be done and funds were really needed, the Vicar's name was to be found in the list of subscribers; and although he was the most generous of men, he did not give indiscriminately.

Mr. Campbell died at Edinburgh on May 5, 1901.

He was elected a Fellow of this Society on February 20, 1878.

Admiral JOÃO CARLOS DE BRITO CAPELLO, who died May 2, 1901, had been elected an Honorary Member of this Society on December 20, 1882. For 26 years he filled the office of Director of the Observatory do Infante dom Luiz at Lisbon, in succession to Fradesso da Silveira.

In 1862 Capello came to England and remained at Kew while a set of magnetometers were being constructed for the Lisbon Observatory, of which he was then first assistant. When these were completed he took them to Lisbon.

His first paper, on the Magnetic Disturbances of 1864, appeared in the *British Association Report* for 1866.

He also published, among other papers, one on a "Cyclone dos Açores" in the *Annaes da Club Militar Naval*, 1893; and one "Sur le mouvement d'un barreau magnétique suspendu par le centre de gravité." See *Terrestrial Magnetism*, 1898.

He represented Portugal at the International Meteorological Congress of Rome (1879), and at the Conference of Munich (1881), and was an active member, first of the Permanent Committee, and then of the International Meteorological Committee, though unfortunately the state of his health of late years precluded his regular attendance.

JAMES CONROY, who died at Londonderry in September 1901, had been a sergeant in the Royal Engineers. He commenced observing for the Meteorological Office, at the School of Military Engineering at Chatham, in the year 1875. Shortly after he retired from the army on superannuation, and went to his native place, Rosenallis, near Mountmellick, Queen's County. Not finding sufficient occupation on his own farm, he went to the north of Ireland as assistant to the County Surveyor of the County Donegal, and took up his residence at Londonderry, whence he furnished observations to the Meteorological Office till the time of his death.

In addition to his official work under the County Surveyor, he had considerable practice as an architect for the Roman Catholic clergy of the district.

He was elected a Fellow of this Society on November 17, 1875.

WILLIAM SANTO CRIMP was born at Ringmore, South Devon, on June 18, 1853, and was educated at home, being considered too delicate to

go to a public school. He evidently had a natural bent for engineering —when only a youth he designed a small scheme of water-supply for the village of Modbury, adjoining the parish in which he lived; and this scheme was subsequently successfully carried out, and is still in operation. On the completion of his education he first served an apprenticeship with a firm of Agricultural Engineers at Modbury, and subsequently came to London as a pupil for two years of the late Mr. Charles Hyde. At the end of 1875 he became an assistant to Mr. Baldwin Latham, under whom he was engaged for a considerable period in making hydro-geological surveys in Surrey. During 1877 he went to Melton Mowbray, and took charge, as Resident Engineer, of the sewerage works for that town.

In the following year he became Resident Engineer under Mr. Latham on the Wandle Valley sewerage scheme for the Croydon Rural Sanitary Authority. This scheme included an important outfall works at Merton, with large pumping station, described by Mr. Crimp in a Paper presented to the Institution of Civil Engineers in 1884.

Towards the end of 1881, on these works nearing completion, Mr. Crimp was appointed Engineer and Surveyor to the Wimbledon Local Board. While at Wimbledon he carried out a large number of works, including the erection of two bridges over the River Wandle.

The whole time he was at Wimbledon Mr. Crimp may be said to have been continuously experimenting on a practical scale with the treatment of sewerage, and he doubtless acquired there that thorough grasp of this difficult subject which was of such assistance to him in after years. He also made many valuable experiments on the treatment of sludge and its disposal, and on the movement of air in sewers.

In February 1890 Mr. Crimp was appointed District Engineer to the London County Council, where he had charge of the Barking Outfall Works under Sir Alexander Binnie. With Sir Alexander's concurrence, he introduced radical changes at Barking in the working of the precipitation tanks, and thereby was successful in reducing the labour involved in removing the sludge from the tanks; and in many other ways he improved the methods of working. He was also engaged in several large street improvements in London, including the formation of Rosebery Avenue.

In July 1894 Mr. Crimp joined the firm of Messrs. John Taylor and Sons, of Westminster; and from that time to his death continued to practise as a Consulting Engineer.

In the summer of 1899 Mr. Crimp was invited by the Municipality of Bombay to visit India, with a view to report on questions arising out of the main drainage of that city, and on a number of other matters affecting the health of the community. He visited India for this purpose, and successfully dealt with many questions on which his advice was required. Whilst in India a number of other municipalities, including Simla, Surat, Cawnpore, and Poona, obtained his advice on numerous questions. He also investigated for the Indian Government the question of underground water supplies within the Presidency of Bombay, and made a voluminous and valuable report thereon.

Mr. Crimp had of late years become an acknowledged authority on all matters of municipal engineering. He was an excellent Parliamentary witness, having so thorough a grasp of the subject that he was able to

answer almost any question with precision. His services were in consequence retained for nearly all the Corporation Bills of recent years.

In April 1901 he contracted a severe chill, which, developing into pleurisy and pneumonia, resulted in his death on the 21st of that month.

Mr. Crimp was Member of the Institution of Civil Engineers.

He was elected a Fellow of this Society on March 19, 1890.

Major FREDERICK HUSSEY DANIEL EYRE was the only son of the late Rev. Frederick Kinneer Eyre, Vicar of Hinton Admiral, and was educated at Eton, and Christ Church, Oxford. He was a Hampshire County Magistrate, and held a commission as Major (V.D.) in the 4th V.B. of the Hampshire Regiment, having been in the Volunteer Service since 1860.

He took careful meteorological observations, and bequeathed his MS. Journals to the Royal Meteorological Society. He was also a good botanist and naturalist, his remarkably accurate memory for names being of great help to him in these studies. As a sportsman he was an excellent shot and a fairly good fisherman, though with regard to the latter sport he almost entirely confined himself to the early salmon fishing on the Avon.

He died on March 29, 1901, in his 60th year.

He was elected a Fellow of this Society on June 15, 1881.

Major LAMOROCK FLOWER was the son of George Flower of the Manor House, Saltford, Somersetshire, and was born on January 7, 1829. He served his articles under Mr. Cruse of Warminster, and was afterwards actively employed in surveying and preparing schemes for railways and other works, in the heat of the railway mania, under Sir John Rennie, and in works of land drainage and improvement under Mr. W. C. Mylne, Engineer of New River Company.

From 1853 to 1856 he had charge of extensive works carried out for improvement of the River Thames, the filter-beds at Stoke Newington, Hornsey, and New River Head, with the engines, engine houses, storage reservoirs at Maiden Lane, etc. Subsequently he served under Sir John MacNeill, in Ireland, and with Mr. Thomas Page laid out and deposited extensive schemes for railways and works. The railway to Epsom Downs was devised and the surveys made by himself, and the Act obtained, the line, after difficulties with contractors, being finished by the Brighton Railway Company.

Major Flower was for some time Professor of Military Surveying at the Cavalry College, Richmond, which was the foundation of the present Staff College. While there he wrote a manual of surveying entitled *Marching Out*, dedicated to H.R.H. the Commander-in-Chief, who ordered it to be supplied to military libraries. He also wrote many books and pamphlets dealing with the water question, and he was the author of many lectures and papers, amongst them "River Lea," read before the Sanitary Institute.

In 1871 he was appointed Sanitary Engineer to the Lea Conservancy Board, an appointment he continued to hold until his death. He was deeply interested in all questions of sewage disposal and water supply, especially the purification of the River Lea, and for the last two years had been busy in forwarding a scheme for intercepting the sewage of the

towns and places in the lower part of the Lea Valley, and carrying it right away from the district. This, it is hoped, will be brought about ere long, and it was his great ambition to see it accomplished. His courtesy and consideration were very much appreciated by the authorities with whom he had to deal.

Major Flower died on May 23, 1901.

He was elected a Fellow of this Society on December 19, 1894, and at the time of his death was a Member of the Council.

Sir JOSEPH HENRY GILBERT was born at Hull in 1817, and was the son of the Rev. Joseph Gilbert of Ongar. A gunshot accident after he had left school resulted in the loss of the sight of one eye, and impaired his health for some time. His college career began at Glasgow University, where he devoted much attention to chemistry, which he studied in the laboratory of Prof. Thomas Thomson. He proceeded to University College, London, and listened there to lectures by Professor Graham, besides working in the laboratory of Dr. Antony Todd Thomson, where John Bennet Lawes, three years his senior, was also a pupil. He next went to Germany to study chemistry under Liebig at the University of Giessen, and he there took the degree of Ph.D. at the same time as Lyon Playfair, afterwards Lord Playfair. On his return to London Dr. Gilbert acted as assistant to his old teacher, Dr. A. T. Thomson, at University College in 1840-41. Subsequently he devoted some time to the study of the chemistry of calico printing and dyeing in the neighbourhood of Manchester. In 1843 the decisive step of his life was taken, for he then became associated with John Bennet Lawes, and assumed control of the chemical laboratory at the Rothamsted Experiment Station, Harpenden. The collaboration thus begun, and destined to be so fruitful in the domain of agricultural research, lasted for the long period of fifty-seven years, and was only terminated by the death of Sir John Lawes on August 31, 1900.

By far the larger part of Sir Henry Gilbert's work was given to the world in papers issued under the joint authorship of Sir John Lawes and himself.

An account of the Rothamsted experiments will be found in the obituary notice of Sir John Bennet Lawes, Bart., *Quarterly Journal*, vol. xxvii., p. 218.

He was elected a Fellow of the Royal Society in 1860, and subsequently received many honorary degrees.

In February 1894 the Prince of Wales at Marlborough House presented both to Sir Henry Gilbert and to Sir John Lawes the Albert Gold Medal awarded them by the Society of Arts "for their joint services to scientific agriculture, and notably for the researches which, throughout a period of 50 years, have been carried on by them at the experimental farm, Rothamsted." In addition to his travels in Europe, Dr. Gilbert visited Canada and the United States in 1882, and again in 1884, in the pursuit of agricultural enquiry. The Lawes Agricultural Trust provides for the periodical delivery in the United States of a series of lectures dealing with the results of the Rothamsted investigations, and at the request of the committee Sir Henry Gilbert discharged this task in 1893.

On the occasion of the celebration of the jubilee of the Rothamsted experiments, which took place at Harpenden on July 29, 1893, a massive silver salver was presented by public subscription to Dr. Gilbert "in commemoration of the completion of 50 years of unremitting labour in the cause of agricultural science." Shortly afterwards he received the honour of knighthood.

He died on December 23, 1901.

He was elected a Fellow of this Society on November 16, 1870, and served on the Council 1880-83, being Vice-President in 1881-82.

RALPH HEAP was born on April 30, 1841, at Rochdale, Lancashire, with which town many of his relatives had long been—and still are—prominently connected. He was the only surviving son of the late Mr. Robert Heap, who married Mary, daughter of Mr. Benjamin Heape. Mr. Ralph Heap, being of delicate health, was educated privately. He matriculated at Wadham College, Oxford, and took the degree of M.A. in 1864. He studied law, and was called to the Bar in June 1866, but never practised.

He resided for many years at Southport in Lancashire, and was an enthusiastic traveller, and, being possessed of ample means, there were few parts of the civilised world that he did not visit at some time or other. He was a great supporter of Literary and Scientific Societies, and subscribed liberally to their funds. In his will he left a bequest of £1000 to found a scholarship for Oriental Languages at his old College. He was never married. His death took place on May 10, 1901, at Bournemouth, and he was interred—in accordance with his special request—at the beautiful cemetery at Mentone, France.

He was elected a Fellow of this Society on November 20, 1889.

Commander HENRY M. LAMBERT, R.N.R., son of Captain G. P. Lambert, Elder Brother of the Trinity House, was born October 15, 1859. He was educated for the sea on board H.M.S. *Worcester*, where from 1874 to 1876 his work as a cadet was successful and promising, and which he left to enter the service of Messrs. Devitt and Moore; from them he passed into the employment of the Peninsular and Oriental Company. In 1894 he obtained the important post of Marine Superintendent to the London, Brighton, and South Coast Railway, at Newhaven, an office he held with conspicuous success until his death on March 23, 1900.

Commander Lambert was keenly interested in meteorological study. His invariable kindness and courtesy in the discharge of his official duties had won him many friends, by whom his untimely death will be much regretted.

He was elected a Fellow of this Society on June 15, 1892.

THOMAS THOMAS MARKS was a native of Carmarthen, and was the son of the late Mr. James Marks, contractor. At his own request he entered some large engineering works in that town, and on the Great Western Railway, with which his father had business transactions.

In 1870 Mr. Marks was appointed Engineer and Surveyor of Lowestoft, and during his term of office he supervised several important

projects, including a scheme in which the drainage was carried out to sea at the Ness Point. Six years later Mr. Marks was appointed Clerk and Engineer to the Llandudno Board of Commissioners, where, under his supervision, important works were carried out.

About ten years ago the Commissioners decided to divide the two offices, and Mr. Marks was offered, but refused to hold one at the same remuneration that he was then receiving for both. Subsequently he started in private practice as an Auctioneer, Surveyor, and Engineer.

Mr. Marks, who died on September 9, 1901, was an Associate Member of the Institution of Civil Engineers.

He was elected a Fellow of this Society on April 19, 1882.

ARTHUR WILLIAM MARTIN was the eldest son of Cyrus James Martin, and was associated with him in business for many years at Cape Town. Modest and unobtrusive to a degree, he shrank from everything approaching public notice. Beyond his general literary studies, in which he found a perennial source of pleasure, almost the only subject which occupied his attention was that of meteorology. Up to within a year or so he had also been an ardent pedestrian. He was esteemed by all who knew him, and of him it may truly be said that "he never made an enemy and never lost a friend."

As regards his personal disposition every one who knew him will agree with one of his friends up country, who, writing of him since his decease, says, "So pure and temperate, so considerate and unselfish, so discreet and intelligent, so courteous and sincere in all his words and actions."

He died suddenly from heart disease on March 23, 1901.

He was elected a Fellow of this Society on June 16, 1880.

Dr. CHARLES MELDRUM was born at Kirkmichael, Banffshire, in 1821, and was educated at the University of Aberdeen, where he proceeded to the degree of M.A. In 1846 he was appointed to the Education Department of the Bombay Presidency, where he remained only two years, before he was transferred to the Mauritius as Professor of Mathematics at the Royal College.

Meteorological observations had, at that time, been carried on in the island for considerably more than a century, but in a spasmodic sort of way. In 1851, however, Professor Meldrum addressed a memorial to Governor Higginson, the result of which was that, on August 1 of that year, a public meeting was held in the Town Hall, Port Louis, and the Meteorological Society of the Mauritius was founded thereat. The Hon. C. J. Bayley was its first president, and Messrs. Meldrum and Bousquet joint-secretaries.

The main meteorological work undertaken was the examination of the logs of all ships visiting the port, so as to collect information tending to the further development of the law of storms. For the first few years little was done. There were great difficulties in finding accommodation and funds for payment of the staff requisite for the necessary calculations.

In April 1855 it was announced that the Home Government had placed the observatory buildings at the disposal of the Society, rent free, while the Admiralty made a grant of £50 towards publication expenses.

The first Government Observer made no observations except during the passage of cyclones. He resigned in 1858.

In the year 1859 meteorological instruments were installed in the old Government Observatory, and in March 1862 Dr. Meldrum was appointed Government Observer. Very soon came on a critical period in the history of the nascent institution. Port Louis, where it was situated, is encircled by hills, and the want of a situation in a more suitable locality was seriously felt. This idea had been broached by Dr. Thom even in 1853. In April 1860 it was recommended that the observatory be sold, and that a new observatory be erected out of the proceeds. This sale was not effected until the arrival of Sir H. Barkly as Governor in 1863. The site fetched £5200, but several years elapsed before the new building came into existence. In 1866 Mr. Meldrum was sent to England to procure plant for the observatory and the necessary instruments for its outfit. In all these negotiations Sir E. Sabine, at that time President of the Royal Society, took an active part. Mr. Meldrum returned to the Colony in 1869, and on Monday, May 30, 1870, the foundation-stone of the new observatory was laid by H.R.H. the Duke of Edinburgh. It was not, however, until the beginning of 1875 that the full outfit of self-recording apparatus for meteorology and terrestrial magnetism came into actual operation.

The observatory was designated as the "Royal Alfred Observatory." Its site, at Pamplemousses, seven miles north-north-east from Port Louis, is not a happy one, as the ground around is marshy and fever-stricken. The first three chief assistants succumbed to the climate, and the present holder of the office is obliged to reside away from the observatory.

Dr. Meldrum's chief work at first was the extraction of meteorological observations from the log of every ship touching at Mauritius, and from this source he amassed a store of facts which he knew well how to utilise. Part of this was employed in the preparation of the *Cyclone Tracks of the Indian Ocean*, a work subsequently published by the Meteorological Council.

Dr. Meldrum will chiefly be known by the persistent energy with which he studied the connection between the sunspot period and the recurrence of the cyclones which too frequently visit the shores of Mauritius. He early established a system of storm warnings for the cyclones approaching the island, and these were speedily found to be of value and were implicitly trusted in the port.

Mr. Meldrum received the degree of LL.D. from his own university. He was elected into the Royal Society in 1876. He received the honour of C.M.G. in 1886. He was for ten years a member of the Government Council of the island. In 1896 he returned to England in very failing health, and after four years of suffering was released in August 1901.

He was elected a Fellow of this Society on April 15, 1868.

Dr. JAMES NICOL was born on May 8, 1815, at Carnwath, Scotland. He qualified for the profession of medicine at Glasgow University, and took his M.D. degree in 1839. He practised medicine at Carnwath and Aberdour, and subsequently went to Llandudno in October 1853. He had not been there long before he realised that the climate of Llandudno was no ordinary one. He forthwith commenced a series of regular

meteorological observations, which he continued for very many years, and subsequently transferred them to the Town Council. The results of these observations fully supported his favourable opinion of the climate of Llandudno.

Dr. Nicol was Medical Officer of Health for more than twenty years.

He was an earnest advocate for the improvement of Llandudno, and mainly through his continued efforts the Marine Drive round the Great Orme was constructed, and the Pier and Pavilion built. He was instrumental in the town having a good system of sewerage, and being provided with a plentiful water supply.

Dr. Nicol was a contributor to the local press, and also published several pamphlets, viz. *The Climate of Llandudno* (which went through several editions), *Llandudno as a Health Resort*, and *Bathing: Its Principles and Practice.*

Dr. Nicol, who had been an invalid for some time, died on February 20, 1901.

He was elected a Fellow of this Society on February 19, 1873.

Miss ELEANOR A. ORMEROD was the third daughter of the late George Ormerod, D.C.L., F.R.S., and was born at Sedbury Park, Gloucestershire, on May 11, 1828. Insects were with her a life-long study. As her father advanced in years she took a large share in the management of the farm and the estate, and this gave her that practical knowledge of agricultural affairs of which her numerous writings subsequently afforded evidence. A shrewd appreciation of the considerable information possessed by farmers and farm labourers, acquired by them in the field, contributed much to the success which Miss Ormerod achieved. She won the sympathy of the farm labourers at Sedbury, and they became her willing helpers in tracing and procuring insects, with specimens of the mischief wrought by them.

About the year 1868 the Royal Horticultural Society, in conjunction with the Science and Art Department, began to form a collection illustrative of insects useful or injurious to cultivators, and to this Miss Ormerod contributed largely for a period of ten years. In recognition of this work the Royal Horticultural Society awarded her the Flora Medal; and later she received silver and gold medals from the University of Moscow for her admirable models of insect injuries to plants.

After her father's death the idea occurred to her of recording the results of sustained observations upon the ravages of insect pests of farm and orchard and garden. Accordingly, early in 1877 she issued a brief pamphlet entitled *Notes of Observations on Injurious Insects*, which she continued annually until her death. This unique series of reports was rendered additionally valuable by the publication in 1899 of a general index to all the reports issued up to that date. The immense losses caused by the serious outbreak of turnip-fly in 1881 led Miss Ormerod to publish her first special report, which dealt with this pest and the means of combating its ravages.

In 1882 she became Honorary Consulting Entomologist to the Royal Agricultural Society, a post which she held for ten years. All the year round daily applications for information reached her from at home and abroad, and it is impossible to estimate the money value of

the losses she was instrumental in preventing by her sound practical advice, generously given to all who cared to ask it.

During the busiest part of her career she found time to write various practical treatises, such as the well-known *Manual of Injurious Insects*, *Handbook of Insects Injurious to Orchard and Bush Fruits*, *Guide to Methods of Insect Life*, *Injurious Insects of South Africa*, *Text-book of Agricultural Entomology*, etc. The Hessian fly—which she identified in English cornfields, it is believed for the first time, in 1886—the wireworm, hop aphis, mustard beetle, and other pests, each in turn formed the subject of special enquiry and of published reports. She distributed gratuitously many thousands of leaflets, notably upon such pests as the ox warble fly and the stem eelworm. Her investigations into the attacks of warble flies, which are so injurious to cattle, have resulted in the saving of immense sums of money to the cattle-owners of this and other countries.

Miss Ormerod took great interest in meteorology, and prided herself on being the first lady Fellow elected by this Society. In 1880 she published a volume entitled *The Cobham Journals*, which contained abstracts and summaries of meteorological and phenological observations made by Miss Caroline Molesworth at Cobham, Surrey, in the years 1825 to 1850. This work is inscribed to the President and Fellows of the Meteorological Society "By their first lady-Fellow," to each of whom she generously presented a copy of the same.

Miss Ormerod for some time prepared the entomological portion of this Society's Phenological Report, and was also for some years a climatological observer of the Society.

In 1900 the University of Edinburgh conferred on her the Honorary Degree of LL.D. This was the first time that a lady had received such an honour in the Scottish capital.

About fourteen years ago a street accident occasioned an injury to Miss Ormerod, which was followed by lameness and almost constant physical suffering. She was never strong in health, and this was a shock to the whole system.

Miss Ormerod died on July 19, 1901.

She was elected a Fellow of this Society on February 20, 1878.

Sir CUTHBERT EDGAR PEEK, the only child of Sir William Henry Peek, the first baronet, was born on January 30, 1855, and succeeded to the baronetcy on the death of his father in 1898. His mother was a Miss Edgar. He was educated at Eton, and Pembroke College, Cambridge, graduating B.A. in 1879. In 1884 he married the Hon. Augusta Louisa, eldest daughter of Viscount Midleton, and sister to the present Secretary of State for War. After leaving Cambridge he went through a course of instruction in astronomy and surveying, and put his knowledge into practice in two journeys across the unfrequented parts of Iceland, taking regular observations of the latitude, longitude, and dip of the needle. On his return to England he established a small observatory in the grounds of his father's house at Wimbledon.

In 1882 he accompanied the British Expedition to Australia to observe the Transit of Venus. After extensive travels in Australia and New Zealand he returned to England in August 1883, bringing with him a considerable collection of curious and interesting objects, which further enriched the museum established by his father at Rousdon.

In 1884 he built the Rousdon Observatory and furnished it with a 6·4 inch Merz-refractor, equatorially mounted, a small transit instrument, and a sidereal clock. From this date he carried on a continuous series of observations of variable stars of long period.

Sir C. E. Peek organised a Second Order Meteorological Station at Rousdon in September 1883, to which numerous instruments have since been added. He paid special attention to the subject of Anemometry. In 1885 he erected a large cup anemometer of the Kew standard pattern upon the water tower, and in 1895 he placed beside it a Dines pressure-tube anemometer, in order to allow of comparison being made of the results of the two instruments. In 1898 he had a specially designed iron tower erected, to which he removed the pressure-tube anemometer. The meteorological results were published in an annual volume, the first of which was for the year 1884.

Sir C. E. Peek was a Fellow of the Royal Geographical and Royal Astronomical Societies, and of the Society of Antiquaries. He was also Secretary of the Anthropological Society.

He was a Member of Council of the Royal Geographical Society, which Society he has endowed with a medal for the advancement of geographical knowledge.

He died on July 6, 1901, at Brighton, where he had been staying for some months, suffering during a greater part of the time from congestion of the brain.

He was elected a Fellow of this Society on June 16, 1880. He was a Member of the Council in 1884-86 and in 1899, and was Vice-President in 1887 and 1900-1901.

FREDERICK PATTISON PULLAR was born at Bridge of Allan on December 20, 1875, and was the only son of Mr. Laurence Pullar, and nephew of Sir Robert Pullar of Perth. He was rather a delicate child, and much of his education was conducted at home under private tutors. Later on his health improved, and his education was continued at the Stanley House School, Bridge of Allan, and the High School of Stirling. Afterwards he attended the Glasgow and West of Scotland Technical College, where he exhibited a marked ability for applied sciences generally. He ultimately entered his father's business, but devoted a good deal of his time to scientific pursuits.

While cruising about in his father's yacht, he, under the guidance of Sir John Murray, commenced to take an interest in oceanographical observations and problems, exhibiting a lively devotion to the practical work carried on at the Marine Biological Station at Millport. He enthusiastically embraced the study of meteorology, and established at his father's residence at Bridge of Allan a complete meteorological observatory. He became a Member of the Scottish Meteorological Society, and sent in reports regularly. He presented a complete set of meteorological instruments to the Scottish Hospital bound for South Africa under Prof. John Chiene. A room in his father's house was fitted up as his own private workshop, in which he had many ingenious and interesting mechanical, electrical, and photographic contrivances, together with considerable geological collections. He was an Associate of the Institution of Mechanical Engineers, and an active Member of the Automobile Club.

In conjunction with Sir John Murray he undertook a systematic bathymetrical survey of all the lochs of Scotland, and here his mechanical knowledge and inventive genius were at once exhibited by the improvements he made in the apparatus for taking the soundings. He also carried out many improvements in the methods of taking temperatures by means of deep-sea thermometers, etc.

Mr. Pullar was a Fellow of the Royal Geographical Society, the Royal Scottish Geographical Society, and the Royal Society of Edinburgh. He was a man of great bodily and mental activity, generous and brave. His friends were justified in believing that a great future lay before him. His promising career was cut short by an act of devotion. On February 15, 1901, while several hundred persons were skating on Airthrey Loch, near Bridge of Allan, the ice gave way and precipitated many of them into the water. Mr. Pullar, who was a powerful swimmer, rushed to the rescue, and, plunging into the water with his skates on, successfully landed three of them, but on attempting to rescue a fourth (a young lady) his strength failed him, and he and his burden were drowned together before help could reach them.

He was elected a Fellow of this Society on March 16, 1898.

BASIL WOODD SMITH was born in London on March 9, 1831. He was intended by his father for the Stock Exchange, but finding the work entirely uncongenial he soon abandoned it. Placed in circumstances which permitted him to give his time and counsel where they were needed, he was able to assist a number of good causes. He lived at Hampstead, and was Chairman of the Bench of Magistrates. He was Hon. Sec. to the Middlesex County Record Society, and, as such, brought out some volumes of the Middlesex County Records, with Mr. J. Cordy Jeaffreson and Mr. A. T. Watson. He assisted the local philanthropic institutions, and was for many years Chairman of the Orphan Working Schools. He was a man of strong religious views, and was largely occupied in the work of the Bible Society, attending the committee meetings with great regularity for a long period. He also took great interest in Palestine exploration, and generally in all questions of Biblical archæology.

Although a good classical scholar, his interests were scientific rather than literary. He was a Fellow of the Society of Antiquaries. He was for many years on the board of managers of the Royal Institution, and attended the lectures with great regularity. He frequently observed with a telescope he had erected on the roof of his house, and was always ready to show it to visitors and answer the questions they put to him.

An intimate friend says of him, "He was often outspoken, and had a hatred of shams and idleness."

He was elected a Fellow of this Society on March 19, 1862.

HAROLD SMITH was born in Hull on March 1, 1841. There is no record of his early life, but he eventually became a partner in the firm of Messrs. Lambert and Smith, Merchants (as his father and brother had been before him).

During this time he resided in Hull, and there, in conjunction with his father and brother, began his meteorological observations. Upon

their deaths he carried on their work of observer, and also as Consul for Italy, receiving from the King of that country the honour of Chevalier, and a decoration.

After his retirement he resided at Kenley, having married a daughter of Robert Hall, and granddaughter of William Brown, of Brown and Atkinson, steamship owners. Despite his retirement, however, his natural energy kept him ever at work, and he devoted much time to his observations and in giving lectures, and generally striving to benefit his fellow-creatures.

From Kenley he removed to Colwyn Bay, North Wales, for family reasons, and there also he continued his observations until shortly before his removal to town for the surgical operation which unfortunately failed to preserve his life.

The first entries of observations made by him are dated in 1876, and from that time forward he became a constant observer, sending his contributions to the late Mr. G. J. Symons, F.R.S.

His natural courtesy and kindliness of nature appear to have endeared him to all who knew him, and to have left their impression in each of the places at which he resided. He died at his residence at Dulwich Park, near London, on February 16, 1901.

He was elected a Fellow of this Society on June 15, 1881.

APPENDIX IV.

BOOKS PURCHASED DURING THE YEAR 1901.

ALLINGHAM, W.—A Manual of Marine Meteorology for Apprentices and Officers of the World's Merchant Navies. 8°. London, 1900.

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BROWN [Dr.], J. C.—French Forest Ordinance of 1669; with Historical Sketch of previous Treatment of Forests in France. 8°. Edinburgh, 1883.—Finland: its Forests and Forest Management. 8°. Edinburgh, 1883.—Forests and Forestry in Northern Russia and Lands beyond. 8°. Edinburgh, 1884.—Forestry in Mining Districts of the Ural Mountains in Eastern Russia. 8°. Edinburgh, 1884.

GARNER, R.—The Natural History of the County of Stafford: comprising its Geology, Zoology, Botany, and Meteorology, 8°. London, 1844.

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PATTERSON, JOHN.—Egypt and the Nile considered as a Winter Resort for Pulmonary and other Invalids. 8°. London, 1867.

PHIPSON, T. L.—Researches on the Past and Present History of the Earth's Atmosphere. 8°. London, 1901.

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ROSS, Capt. J. C.—A Voyage of Discovery and Research in the Southern and Antarctic Regions during the years 1839-43. 2 vols. 8°. London, 1847.

SCHULZE, F. W.—On Periodical Change of Terrestrial Magnetism. 8°. Shanghai and London, 1879.

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WEBSTER, T.—The Principles of Hydrostatics: an Elementary Treatise on the Law of Fluids, and their Practical Applications. 8°. 4th ed. London, 1865.

APPENDIX V.

DONATIONS RECEIVED DURING THE YEAR 1901.

Books and Pamphlets.

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Athens, Observatoire National.—Annales, tome iii.

Bangalore, Central Observatory.—Mysore Meteorological Memoirs, No. 1.

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Batavia, Magnetical and Meteorological Observatory.—Observations, 1899. —Rainfall in the East Indian Archipelago, 1899-1900.

Berlin, Deutsche meteorologische Gesellschaft.—Meteorologische Zeitschrift, Dec. 1900 to Nov. 1901.

Berlin, Gesellschaft für Erdkunde.—Verhandlungen, Band xxvii. No. 9 to Band xxviii. No. 9.—Zeitschrift, Band xxxv. No. 4 to Band xxxvi. No. 4.

Berlin, Königlich-Preussisches meteorologisches Institut.—Abhandlungen, Band i. Nos. 6-8.—Bericht über die Thätigkeit des Königlich-Preussischen meteorologischen Instituts im Jahre 1900.—Ergebnisse der Beobachtungen an den Stationen II. und III. Ordnung, 1896, Heft 3; 1900, Heft 1 and 2.

Bermuda, General Register Office.—Report, 1900.

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Bognor, Climatological Society.—Reports for the years 1898, 1899, and 1900.

Bombay, Government Observatory.—Magnetical, Meteorological, and Seismological Observations, 1898-99.

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Cairo, Société Khédiviale de Géographie.—Bulletin, Vme série, Nos. 8-9.

Cairo, Survey Department, Public Works Department.—Meteorological Observations at Abbassia, Oct. 1900 to Sept. 1901; Alexandria, Jan. to Oct. 1901; Assiut, Oct. 1900 to Sept. 1901; Assuan, Oct. 1900 to Sept. 1901; Omdurman, Oct. 1900 to Oct. 1901; and Port Said, Nov. 1900 to Oct. 1901.—Report on the Meteorological Observations made at the Abbassia Observatory, Cairo, during the years 1898 and 1899.

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KAZAN, OBSERVATOIRE MAGNÉTIQUE DE L'UNIVERSITÉ IMPÉRIALE.—Observations, Jan. to April 1900.

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LISBON, MINISTERIO DA MARINHA E ULTRAMAR.—Album de estatistica graphica dos caminhos de Ferro-Portuguezes das Provincias Ultramarinas, 1898.

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APPENDIX VI.

REPORTS OF OBSERVATORIES, ETC., FOR 1901.

THE METEOROLOGICAL OFFICE.—W. N. Shaw, F.R.S., Secretary.

In the course of the year a considerable alteration in the internal arrangement of the Office has been introduced, in order to put the supply of information

to the public upon a satisfactory basis, in view of the large accumulation of records in manuscript and in print from all parts of the world. At the same time a Memorandum has been prepared for issue, setting forth the provision made for the supply of information to the public, which includes a list of stations from which original records are received. The Memorandum is included, as an appendix, in the *Report of the Council* for the year 1900-1901, and separate copies can be obtained on application at the Office.

In the Marine Branch the preparation of a series of monthly Wind Charts for the coastal regions of South America has been completed, and the charts will shortly be published by the Admiralty. They give wind-roses for different small sectional areas of the coastal regions referred to, together with mean isobars and a few meteorological notes.

A series of monthly *Pilot Charts* of the North Atlantic and Mediterranean has been issued during the year commencing with April 1901. The Charts contain statistical information as to the meteorology of the regions indicated, for the month referred to, and there is added the most recent information as to the position of ice in the Atlantic, contributed by commanders of vessels crossing the ocean. In the more recent numbers issued, magnetic lines have been added to the Chart. The Charts are presented to the officers of vessels who are on the list of observers for the Meteorological Office, and, by arrangement with the Board of Trade, copies are on sale at 6d. each, to officers of the merchant vessels, at the Mercantile Marine Offices of the Board of Trade, at a number of ports in the United Kingdom. They are also on sale to the public by the Agents for the publications of H.M. Stationery Office at the same price, 6d. per copy, or 5s. for the set of 12 Charts for a year; but if sent by post, a charge is made by the Agents for packing and postage. In the coming year the *Pilot Charts* will include inset charts showing mean sea-surface temperatures of the North Atlantic for the month next but one before the date of issue, derived from observations supplied by captains and officers of vessels observing for the Office.

Another new publication, prepared during the year, is a volume entitled *Temperature Tables for the British Isles*. The primary occasion for the publication is the completion of 30 years' records of the self-recording instruments at the Observatories in connection with the Office. Advantage has been taken of the occasion to prepare from the records of the Observatories the averages of daily mean temperature for the 30 years, together with the extremes between which the averages are taken, and the means and extremes of daily maxima and minima. These are tabulated and also represented by curves which are reproduced in the volume. They are supplemented by curves representing the diurnal variation of temperature at the same Observatories, based upon mean hourly values for 25 years, which have already been published. In order to make the survey of the temperature relations of the British Islands more complete, tables of the averages and extremes for not less than 15 years of maximum and minimum temperature for each month of the year have been prepared for 117 stations, from records preserved in the Office, with some additions, and have been added to the volume. The mean temperatures for the month have also been computed from the averages of maxima and minima, upon a method in use in the *Weekly Weather Report*. The volume of *Temperature Tables* will be issued early in the new year.

The usual publications of the Office have been continued as heretofore. The only modification which has been introduced into the *Daily Weather Report* is the substitution of maps of the British Isles, showing the thirty year averages of rainfall and rain days and extremes of temperatures respectively, for the maps of mean maxima and minima on p. 2 of the Report. As the close of 1900 completed another five-year period, the usual five-year summaries of tempera-

ture and rainfall were issued as appendices to the volume of the *Weekly Weather Report* for 1900. The volumes of *Hourly Means* at the five Observatories in connection with the Office, and of *Observations at Second Order Stations* for 1898, have been issued.

In connection with the continuation of the Monthly International Balloon Ascents, Dr. Hergesell of Strassburg has requested the further co-operation of observers in this country, in the matter of cloud observation, and has asked for observations from two stations in England, one on the east and one on the west coast, two in Scotland, and two in Ireland. In compliance with this request, arrangements have been made for observations to be forwarded from Greenwich, Falmouth, Valencia, Bidston, Aberdeen, and Glasgow. Dr. Hergesell specially desired instrumental measurements of the actual or apparent velocities of clouds, but at present no arrangement for furnishing these measurements has been concluded.

In connection with the National Antarctic Expedition, the Office was called upon to undertake the arrangements for the supply of meteorological instruments, including not only those furnished to the expedition by the Admiralty, but also the more experimental instruments provided by the Committee of the expedition. The work included the design of a sunshine recorder suitable for recording at any hour of the twenty-four, and of the cards suitable for the instrument. For the information of the members of the expedition, at the request of the Committee, a copy of the data contained in the meteorological logs preserved in the Office for the region between lat. 50° S., and 60° S., and between long. 120° E., eastward to 130° W., was prepared in the Office.

At the request of the Royal Society, the meteorological observations made on the *Southern Cross*, the ship of the expedition sent out by Sir G. Newnes, and at Cape Adare, were tabulated and prepared for the press.

In October 1901, recommendations approving a suggestion by the Council for initiating an inquiry into the occurrence and distribution of fog in the London area, and placing a sum of money at the disposal of the Council for the inquiry, under certain conditions, were adopted by the County Council of London. The Council at once took steps to initiate the inquiry, and appointed Capt. Carpenter, R.N., D.S.O., a member of the Council of the Royal Meteorological Society, to take charge of the inquiry, under their direction. By the middle of November, regular observations were organised at a number of the stations of the Metropolitan Fire Brigade, at some of the Police stations, and at Battersea Park and Regent's Park. Subsequently observations were organised at some of the Coastguard stations in the Thames estuary, and continuous records of temperature have been obtained from Banstead Downs, from the top of the Victoria Tower, and the Golden Gallery of St. Paul's Cathedral. The results of the observations will be summarised in a Report to the Council at the conclusion of the winter.

The arrangement for the issue of forecasts during the harvest season continued as in previous years, and a considerable number of agriculturists and others again availed themselves of the arrangement.

The Council have received from the Foreign Office, month by month, a number of sets of observations from the Nile valley and the great African lakes. They have had under consideration the means of making these observations, and others from remote British Colonies and possessions, available for public information, and have in contemplation the preparation of an annual volume, giving a summary of such observations. The arrangements for the preparation of the volume are not yet completed.—*February* 25, 1902.

ROYAL OBSERVATORY, GREENWICH.—W. H. M. Christie, C.B., M.A., F.R.S., Astronomer-Royal.

The meteorological observations have been continued on the same general lines as in preceding years, with the addition of special observations of clouds on the days appointed in each month for international balloon ascents, and these observations have been transmitted regularly to the Meteorological Office.

The temperature of the air ranged between 87°·9 on July 19, and 20°·4 on February 15. The annual mean temperature was 49°·3, being 0°·2 below the average. The monthly mean temperature in February was 3°·5 below the average, and in March 2°·4 below, whilst in July the temperature exceeded its average by 2°·3. The sunshine in the year amounted to 1567 hours out of a possible duration of 4459 hours, thus showing a percentage of 35. In the five months April to August (inclusive) the amount recorded was 1129 hours out of a possible duration of 2338 hours, and the percentage amounted to 48. Rain fell during the year on 123 days to the total amount of 20·293 ins., being 4·245 ins. below the average for the 50 years 1841-90. In the seven years 1895-1901 the total deficiency of rainfall amounts to 23·705 ins.—*April* 2, 1902.

ROYAL OBSERVATORY, EDINBURGH.—Ralph Copeland, Ph.D., F.R.S.E., Astronomer-Royal for Scotland.

The usual meteorological observations have been made throughout the year by the staff of the Observatory. They include readings, twice daily, of the barometer, dry- and wet-bulb thermometers, and estimates of wind and cloud, and daily readings of the shaded and exposed maximum and minimum thermometers. A monthly copy of these readings and estimates has been supplied to the Scottish Meteorological Society for the use of the Registrar-General for Scotland, and the monthly means have been regularly published in the Registrar's Reports, along with the similar results from a large number of other stations in Scotland. A weekly return of maximum and minimum shade temperatures and rainfall has also been furnished to the Registrar-General at his request.

The King barograph and the Robinson self-recording anemometer have been kept in operation continuously. A Campbell-Stokes sunshine recorder was added to the equipment in the last month of 1900, and a complete record of bright sunshine has been obtained for the year 1901. A summary of the wind velocities, as shown on the anemometer, and of the amount of sunshine has been sent each week to the *Scotsman* newspaper for publication. The number of hours of sunshine amounted to 1594 for the year, being 409 in excess of the mean of the previous 10 years recorded by a similar instrument, which has been kept in operation by Mr. R. C. Mossman at his residence in Blacket Place, Edinburgh, since August 1890.—*January* 31, 1902.

NATIONAL PHYSICAL LABORATORY (KEW OBSERVATORY), RICHMOND, SURREY.—R. T. Glazebrook, Sc.D., F.R.S., Director; and Charles Chree, Sc.D., F.R.S., Superintendent of Observatory Department.

The several self-recording instruments for the continuous registration of atmospheric pressure, temperature of air and wet bulb, wind (direction, pressure, and velocity), bright sunshine, and rain have been maintained in regular operation throughout the year, and the standard eye observations for the control of the automatic records have been duly registered. The tabulations of the meteorological traces have been regularly made, and these, as well as copies of the eye observations, with notes of weather, cloud, and sunshine, have been transmitted, as usual, to the Meteorological Office. With the sanction of the Meteorological

Council, data have been supplied to the Royal Meteorological Society, the Institute of Mining Engineers, and the editor of *Symons' Monthly Meteorological Magazine.*

Bright Sunshine.—In previous years the entries for the several months under the heading "Mean percentage of possible sunshine," have been the means of the 28 to 31 percentages for the individual days of the month. Similarly the mean entered at the foot of the column has been the arithmetic mean of the 12 mean values attributed to the several months. While a perfectly logical way of presenting the facts, it differs from the practice usually followed, which is equivalent to defining the mean percentage for any period of n days—whether a month or a year—as 100 × (total recorded hours of bright sunshine in the n days) ÷ (total possible number of hours in the n days). In accordance with an arrangement with the Meteorological Office, it is intended to publish the results from both methods for some years, before finally adopting the newer method, which in 1901—as in 1900—gives for the annual mean percentage a value greater than that given by the old in the proportion roughly of 11 to 10.

Electrograph.—This instrument worked in a satisfactory manner till September, when the action became indifferent, and all parts of the apparatus, inside and outside, were dismounted and thoroughly cleaned. Thereafter the working was much improved Scale value determinations were made on May 10, September 23, December 6 and 10, and in addition the potential of the battery has been tested weekly. Forty cells only have been employed throughout the year, giving about 30 volts.

Atmospheric Electricity.—The comparisons of the potential, at the point where the jet from the water-dropper breaks up, and at a fixed station on the Observatory lawn, have been continued, and the observations have been taken every day when possible, excluding Sundays and wet days, and the ratios of the "curve" and the "fixed station" readings have been computed.

Fog and Mist.—The observations of a series of distant objects have been continued. A note is taken of the most distant of the selected objects, which is visible at each observation hour. At the request of the Meteorological Council, extra observations of surface fog and darkness have been made in connection with the investigation of "London Fogs," undertaken by the Office and the London County Council.

Seismological Observations.—Prof. Milne's "unfelt tremor" pattern of seismograph has been maintained in regular operation throughout the year. The largest "disturbances" recorded took place on June 24, when the maximum amplitude was 8·4 mm. (6·7 seconds of arc), and on August 9, when the maximum was 8·0 mm. (6·0 seconds of arc). A detailed list of the movements recorded from January 1 to December 31, 1901, was made and sent to Prof. Milne, and will be found in the *Report of the British Association* for 1902, "Seismological Investigations Committee's Report."

The mean temperature for the year was 49°·3, and the extremes ranged from a maximum of 87°·6 on July 19, to a mimimum of 19°·0 on January 9. The highest mean monthly temperature was 65°·8 in July, and the lowest 36°·4 in February. The highest temperature in the sun's rays (black bulb *in vacuo*) was 147° on July 17, and the lowest temperature on the grass was 8° on February 14.

The mean percentage of sunshine was 33 (old method), and 36 by new method, the average for the past 20 years being 29 (old method), and 32 by the new. The highest monthly percentage was 52, recorded in April, May, and August.

The rainfall for the year was 18·735 ins., being 5·3 ins. below the average, and, with the exception of 1898, the lowest rainfall since 1870. December

with 3·255 ins. was the wettest month, the driest month being May, with 0·450 ins.; but the low total of 0·470 ins. in November is more noticeable, as it is 1·66 ins. below the average for that month, and is the smallest value for November yet recorded here.—*April* 10, 1902.

RADCLIFFE OBSERVATORY, OXFORD.—Arthur A. Rambaut, M.A., D.Sc., F.R.S., Radcliffe Observer.

The meteorological observations and automatic registrations have been maintained as usual, and the results have been regularly sent, as heretofore, to the Meteorological Office (by daily telegram), the Registrar-General, the local newspapers, and to sanitary and other public authorities on request, as well as some private inquirers. This Observatory has also, during the year 1901, shared in the scheme of taking observations of the form and motion of clouds, in connection with the balloon ascents of the International Aeronautical Committee.

The five underground platinum-resistance thermometers have been in use throughout the year. A new switchboard with copper blocks, instead of mercury contact, was on May 23 substituted for the old switchboard, where the amalgamation had, in time, penetrated some of the copper-strip connections. Also, on November 19, a further improvement was effected by the use of new leads of continuous copper cord covered with rubber tubing, and an improved contact piece.

The standard barometer, Newman 1220, which had been in use without interruption since the year 1879 (when it was repaired by Messrs. Negretti and Zambra), had shown signs of decay in the brass-work around the cistern and tube. It was, therefore, dismounted on September 27, and sent to the above-mentioned instrument-makers. All the metal parts were repaired, the mercury cleaned, the tube reboiled, and a new basin thermometer fitted. After comparison with Messrs. Negretti and Zambra's standard, the barometer was returned to the Observatory and remounted on October 22, in its old position. During its absence, readings were taken from a marine barometer, Adie 886, kindly lent by the Meteorological Council. This instrument, however, proved in practice to be unusually sluggish in action, requiring much tapping to assist the mercury past the choke in the tube.

The annual inspection of the automatic instruments, with comparison of the thermometers with a Kew standard, was made by Mr. Constable, of the Kew Observatory, on behalf of the Meteorological Office, with satisfactory results. The zero points of the various thermometers were also checked independently during the winter in melting snow.

The following are the chief characteristics of the weather noted at Oxford in the year 1901 :—

The mean reading for the year of the barometer was 29·732 ins., being 0·006 ins. above the mean for the preceding 46 years. Highest reading, 30·437 ins. on November 25; lowest, 28·517 ins. on December 24; a range of 1·920 ins.

The mean temperature of the air was 48°·9, being identical with the mean for the preceding 73 years. Maximum, 89°·0, occurred on July 19; minimum, 17°·4, on January 9. The minimum on the grass was 11°·2 on January 9.

The differences of the mean monthly temperatures from the corresponding means deduced from the observations of the preceding 73 years, are given in the following table :—

January	+0°·1	May	+0°·9	September	+1°·6
February	−3·5	June	+0·1	October	+0·5
March	−2·3	July	+3·7	November	−2·8
April	+1·9	August	+1·1	December	−0·9

As in the previous year, the month of July was very warm ; the screened thermometer indicated readings over 80° on 8 days ; whilst the mean of the daily maxima for July 16-21 was 84°·6. The mean maximum temperature for July 1901 was 74°·9.

The bright sunshine registered in 1901 by a Campbell-Stokes recorder amounted to 1602 hours, being 138 hours above the average for the previous 21 years. The following table gives the monthly differences from the mean :—

	hrs.		hrs.		hrs.
January	0	May	+54	September	−14
February	−21	June	+33	October	− 1
March	−37	July	+18	November	+ 4
April	+51	August	+37	December	+14

The rainfall in the year amounted to 23·181 ins., or 2·940 ins. below the mean for the preceding 86 years. The monthly differences from the mean are given in the following table :—

	ins.		ins.		ins.
January	−0·901	May	−0·620	September	−0·760
February	−0·619	June	−0·636	October	−1·578
March	+0·194	July	+2·190	November	−1·804
April	+0·394	August	−0·218	December	+1·418

In the early part of January, floods were experienced in the neighbourhood of Oxford. Whilst on three days in July the rainfall exceeded 1 inch, viz. July 24th, 1·640 in. ; 25th, 1·501 in. ; 27th, 1·198 in. ; as a result, some of the streets and roads in the city and basements of houses were inundated.—*February* 26, 1902.

Royal Meteorological Institute of the Netherlands.—We have been informed that by a Royal Decree of March 21, 1902, a Section of Terrestrial Magnetism and Seismology has been formed at the Royal Meteorological Institute of the Netherlands, at De Bilt, and that the Director of the new Section is Dr. Maurits Snellen, the Director-in-Chief of the Institute being C. H. Wind.

Weather Bureau, Queensland.—We regret to learn that the Queensland Government, owing to the necessity for reducing in every branch of the public service the estimates of expenditure of the State, have found themselves obliged to give up the Weather Bureau at Brisbane, and to dispense with the services of Mr. Clement L. Wragge, the Government Meteorologist, and also of the entire staff.

Rainfall at San Fernando, Spain.—The Appendix to the *Anales* of the Instituto y Observatorio de Marina de San Fernando for 1899 contains the monthly and yearly amounts of rainfall from 1805 to 1899. The observations for the earlier years were not very complete, but the average monthly rainfall for the 50 years, 1850-1899, was as follows :—

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ins.	ins.	ins.	ins.	ins.	in.	in.	in.	ins.	ins.	ins.	ins.	ins.
3·54	2·97	3·52	2·33	1·71	0·41	0·05	0·17	1·13	3·40	4·25	4·18	27·66

The greatest yearly rainfall was 48·69 ins. in 1871, and the greatest monthly fall was 14·06 ins. in November 1871. The heaviest fall in one day was 3·88 ins. on November 12, 1898.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

March 19, 1902.

Ordinary Meeting.

WILLIAM HENRY DINES, B.A., President, in the Chair.

DANIEL BUCKNEY, 51 Highbury Park, N.;
ARTHUR SHAW BUTTERWORTH, Assoc.M.Inst.C.E., Hythe, Kent;
JAMES HENRY CHESSHYRE DALTON, M.D., Adams Road, Cambridge; and
ABRAHAM THOMAS, M.B., 22 North Parade, Aberystwith,
were balloted for and duly elected Fellows of the Society.

The following communications were read:—

1. "'LA LUNE MANGE LES NUAGES'—A NOTE ON THE THERMAL RELATIONS OF FLOATING CLOUDS." By W. N. SHAW, M.A., F.R.S. (p. 95).

2. "THE PREVALENCE OF GALES ON THE COASTS OF THE BRITISH ISLANDS DURING THE 30 YEARS, 1871-1900." By FREDERICK J. BRODIE, F.R.Met.Soc. (p. 121).

April 16, 1902.

Ordinary Meeting.

WILLIAM HENRY DINES, B.A., President, in the Chair.

SERGE BORDITSCHEWSKY APOSTOLOFF, 8 Victoria Square, S.W.;
HENRY BOURHILL, Groot Olifants River, viâ Pretoria, Transvaal;
SURGEON-MAJOR CHARLES LENOX CUNNINGHAM, Weymouth;
CHARLES HENRY JOLLIFFE, F.R.M.S., St. Helens, Lancs.; and
JOHN HENRY TRIPE, M.R.C.S., 232 Richmond Road, Hackney, N.E.,
were balloted for and duly elected Fellows of the Society.

CAPTAIN D. WILSON-BARKER, F.R.S.E., gave a Lecture on "CLOUDS," which was illustrated by lantern slides (p. 159).

On the motion of Dr. H. R. MILL, seconded by Mr. W. N. SHAW, a vote of thanks was passed to Capt. Wilson-Barker for his Lecture.

CORRESPONDENCE AND NOTES.

The Barograph Trace during the Typhoon, August 2-3, 1901.—The following letter from the Rev. Louis Froc, the Director of the Zi-Ka-Wei Observatory, Shanghai, China, will be read with great interest:—

"SIR—I have read with great interest in the *Quarterly Journal*, vol. xxviii., p. 39, the Note on the "Barograph Trace during the Typhoon of August 2-3, 1901," which has been reprinted in *Nature*, March 13, 1902. I am very glad to be able to confirm the remark concerning the *extraordinarily low* level of the glass. The more so as the true reading must still be considerably lowered. I am in possession, through the kindness of Capt. George Payne, commander of the s.s. *Laisang*, of a copy of the same trace. It is identical to that printed in the *Quarterly Journal*, with no correction whatever for error, as far as the *barograph*

curve is concerned; the *mercurial* portion of the readings (if you allow the term) having been corrected according to the barograph, as is said in the Note.

"May I endeavour to show that the process should be reversed? It is not difficult to find the true index error of the mercurial barometer, which is small, and infer that of the barograph, which is, or at least *was*, rather large at the time of the typhoon. This will be done by comparison with two first-class Observatories.

I. *Comparison with Taihoku (Formosa).*

"According to the circumstantial report sent here by Capt. G. Payne, the steamer was on August 1st, at noon, in long. 120° 47′ and lat. 25° 19′, about 35 miles to west by north from the Observatory of Taihoku, the central station of Formosa. At 2 p.m. she was lying at about 30 miles west-north-west or north-west of the same place. Now the barogram on board was reading about 30·03 ins. (see trace in the *Quarterly Journal*), a figure which would be very high, at that season, in that latitude, and especially in the vicinity of a typhoon. At the same hour, the Central Observatory was reading 29·59 ins., all reductions duly made for sea-level and standard gravity. Several trustworthy and well-verified observations taken at or near Foochow, on board French men-of-war, and at the Arsenal, show a difference of 0·16 in. for the hundred miles between the China coast (Min. River), and the north of Formosa. This gives a gradient of 0·96 in. But of course the slope was steeper nearer the typhoon, as shown by the isobars traced in the pamphlet '*De Witte Typhoon*.' Let us suppose it to have been as steep as 0·15 in. in the neighbourhood of Taihoku: this would mean 0·07 in. for 30 miles: then the true pressure on board would have been 29·59 + 0·07 = 29·66 ins. Now the *mercurial* barometer on board, at the same date and hour (attached thermometer 83°) read 29·78 ins., reduction to 32° − 0·143 ins., corrected reading, 29·637 ins. The index error of the mercurial would have been about + 0·02 in. (by + I understand a quantity to be added).

"The barograph read 30·03 ins., and consequently was too high by 0·37 in. or very nearly that figure.

II. *Comparison with Hong-Kong.*

"At our request Capt. George Payne, on his first stay at Hong-Kong, after the typhoon (Sept. 1901), kindly made careful comparisons between his *mercurial* barometer and that of the Kowlong Observatory, as published in the papers, on five consecutive days (13-17). The differences range from + 0·05 in. to 0·03 in., the mean being + 0·04 in. not reduced to sea-level. Correcting for the height of the cistern on board, the difference would be close to + 0·02 in. It is seen that the two comparisons fairly agree in the result. Six weeks earlier, in the centre of the typhoon, the same mercurial, read off very attentively, had 27·12 ins. attached thermometer 80°. This gives with index error + 0·02 in. = 27·14 ins. correction to 32° F. = 0·124 ins., true pressure, 27·016 ins. The trace published in the note has 27·35 ins., and therefore is too high by 0·334 in.

"The agreement of the correction found by the two methods seems quite satisfactory. Besides that, it is safer to correct a barograph from a mercurial than the reverse. I will note that the correction of this barograph may possibly not have been constant, as the pen fell to the bottom of the box during the storm, and the instrument had to be adjusted afterwards in consequence. I think I am justified in maintaining the figures I have given in the '*De Witte Typhoon*,' p. 4, viz. 27·02 ins. for the minimum, which exceeds all the low readings quoted in the *Quarterly Journal*.

"Hoping the singularity of this *well-established* low pressure will serve as an excuse for the length of this letter, I have, Sir, the honour to be, yours very sincerely, Louis Froc, S.J., Director, Zi-Ka-Wei Observatory, *April* 22, 1902."

Cumulus Clouds formed by Smoke.—In the last number of the *Quarterly Journal* (p. 112), an extract from the *Monthly Weather Review* is printed describing the formation of a *cumulus* cloud over a column of smoke. I remember noticing a similar formation some years ago at Bisley. It was a warm July day, and a heather fire was burning a mile or two away behind the Stickledown butts. The fire went on most of the day, but for a time during the afternoon the column of smoke-heated air was capped by a well-marked little *cumulus* cloud.—HENRY MELLISH.

Loss of Life in the United States by Lightning.—A paper on this subject by Prof. A. J. Henry has been issued by the U.S. Weather Bureau. The period dealt with is the 11 years 1890-1900, during which the total number of deaths by lightning were :—

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
3	5	48	157	555	974	1060	795	227	54	11	3

The average annual number of deaths is 377.

The results for the earlier years are incomplete. The figures for 1900 are interesting. During that year 713 persons were killed or received fatal injuries. Of this number 291 persons were killed in the open, 158 in houses, 57 under trees, and 56 in barns. The circumstances attending the death of the remaining 151 are not known. 973 persons were more or less injured by lightning stroke during the year. Of this number 327 persons received their injuries while in houses, 243 in the open, 57 in barns, and 29 under trees. The circumstances attending the injury of the remaining 317 cases are not known.

The greatest mortality by lightning, considering both unit area and density of population, is in the Ohio Valley and the Middle Atlantic States; if, however, density of population only be considered, it is in the Upper Missouri Valley and the Middle Rocky Mountain region. The record of deaths by lightning in the Middle Rocky Mountain region is rather surprising, in view of the vast extent of territory involved, the diversified character of its topography, and the sparsity of its population.

The occurrence of thunderstorms in the United States is not limited to the warm season, although the great majority of such storms happens in the months of June, July, and August. Winter thunderstorms are not infrequent in the Gulf States, and occasionally extend north-eastward along the Atlantic Coast to Massachusetts. At the close of winter the region of most frequent thunderstorms is in the Lower Mississippi Valley. In the spring months the area of greatest frequency extends rapidly northward, overspreading the Upper and Middle Mississippi and the Missouri Valleys by the end of April. The rainy season of the Great Plains region and the north-eastern Rocky Mountain Slope sets in about the end of April, and from that time to the middle or end of July thunderstorms are of frequent occurrence. The season of greatest thunderstorm frequency east of the Alleghanies, especially in New England, does not set in until about the 1st of July, but lasts well into September.

The author concludes with some general instructions respecting safety during the occurrence of thunderstorms :—"It is not judicious to stand under or near trees during thunderstorms, in the doorway of barns, close to cattle, near chimneys and fireplaces, or near the terminus of a wire clothes-line. Avoid suspending the latter between a corner of the house and a convenient tree; rather let it be hung from one tree or post to another. On the other hand, there is not much sense in going to bed or trying to insulate oneself in feather beds. Small articles of steel, also, do not have the power to attract lightning, as it is popularly put, or determine the path of discharge.

RECENT PUBLICATIONS.

Clouds and Weather Signs. By Commander D. WILSON-BARKER, R.N.R. Illustrated with original photographs. London, 1902. 8vo. 31 pp.

This is the reprint of a paper from *Knowledge*, and has been attractively and neatly got up. The illustrations show up very clearly. Captain Wilson-Barker has made a special study of cloud forms, and it is very convenient to have his paper on this subject available in such a handy form.

Die Schwankungen der Niederschlagsmengen in grösseren Zeiträumen. Von J. HANN. (Aus den Sitzungsberichten der Kaiserl. Akademie der Wissenschaften in Wien: Mathem.-naturw. Classe: Bd. CXI., Abth. II*a*. Februar 1902.)

This is a very elaborate paper, reaching to 120 pages. The stations dealt with are three: Padua (1725-1900), Klagenfurt (1813-1900), and Milan (1764-1900), but of the last-named only the yearly totals are used. Dr. Hann at first discusses the Padua records, which are peculiar, but fairly accordant *inter se*. From 1838 to the present time the receiving surface is octagonal, being the roof of the meridian building. The records from Klagenfurt and Milan do not call for so much discussion as to continuity.

It may be interesting to say that Dr. Hann does not find that the figures support the sun-spot period. He also investigates Brückner's 35-year period, and finds that the dry periods last longer than the wet (21 to 15 years), and the wet periods vary more from the mean than the dry.

Journal of the Scottish Meteorological Society. With Tables for the year 1899. Vol. XII. Third Series. No. XVII. 8vo. 114 pp. Edinburgh, 1902.

In addition to the usual tables of meteorological results for the year 1899, and the reports of the Council read at the meetings of the Society on July 18, 1900, March 21 and July 24, 1901, this No. contains three papers, viz.:—

(1) "Fogs on the Coasts of Scotland," by Dr. Buchan (10 pp.). This is a discussion of the observations of fog made at 65 lighthouses round the Scottish coasts during the 12 years 1889-1900. The number of fogs which have occurred at the different points of the coast represented by the lighthouses is extremely irregular. The absolutely largest number was 1441 at Barrahead, and the smallest 34 at Kyleakin in the Narrows of Skye. The numbers of fogs are large at places where the height exceeds 200 feet, while the smallest numbers have occurred at places little elevated above the sea, and at the same time more or less protected from the open ocean. The maximum number of fogs occurs almost entirely in June, while the minimum occurs in the winter time, generally in December. The average duration of separate fogs is 7 hours, the number rising to 8 hours in June, September, October, and November.

(2) "Storms on the Coasts of Scotland," by Dr. Buchan (8 pp.). This paper has been worked upon the same lines as the preceding one, the data being furnished by the returns from 65 lighthouses for the 20 years 1881-1900. For all Scotland, the month of maximum number of storms is 53 for December; and the minimum, 5 for June, which is only very slightly less than July. The maximum duration of storms is 26, in October, and the minimum 18 hours, in June; the average for the year is 24 hours.

(3) "Note on the Number of Gales observed at the Ben Nevis Observatory," by A. Rankin (3 pp.). The author gives a table showing the number of hourly observations at which the force of the wind was noted as above 6 on the Ben Nevis scale of 0 to 12, for the 13 years 1884-1896.

The totals for each month were:—

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
640	489	336	301	115	101	48	116	118	233	526	382	3405

The totals for each hour were:—

	1	2	3	4	5	6	7	8	9	10	11	12
A.M.	164	153	149	146	138	141	154	157	163	147	150	139
P.M.	138	116	115	109	110	131	129	134	151	149	156	166

The 3405 cases of gales are not distributed uniformly over the hours of the day, but they form a distinct diurnal curve, with two well-marked maxima and minima.

Symons's Meteorological Magazine. Edited by HUGH ROBERT MILL, D.Sc., LL.D. April—June 1902. 8vo.

The principal articles are: "The Sun Pillar of March 6" (3 pp.). An exceptionally brilliant example of a sun pillar was observed over the south-west of England on the evening of this day.—"The Rainfall of Madeira" (2 pp.). This article contains tables giving the monthly totals and number of rainy days and maximum falls at Funchal for the 5 years 1896-1901.—"On the Use of our Rainfall Tables" (2 pp.).—"A New Kite for Meteorological Purposes," by W. H. Dines (2 pp.). This is a description of a modified form of the Hargreave kite designed by Mr. Dines. "The Four Months' Rainfall of 1902" (1 p.).—"The Five Months' Rainfall of 1902" (1 p.). These two articles deal with the aggregate rainfall for January to April, and January to May, and give the difference from the average, and also the percentage of the average at a number of stations in the British Isles.—"The Probable Weather of the Last Week of June" (4 pp.). This article deals with the chances of rain falling on the days fixed for the Coronation, June 26 and 27.—"The West Indian Volcanic Eruptions and Atmospheric Phenomena," by R. H. Curtis (3 pp.).

Temperature Tables for the British Islands. Daily Means for the Thirty Years 1871 *to* 1900, *with Diagrams and Additional Tables.* Published by the Authority of the Meteorological Council. Official No. 154. London, 1902. 4to. 120 pp.

This volume is divided into two parts. The first part consists of the daily results derived from 30 consecutive years' observations from self-recording thermometers at the four observatories in connection with the Meteorological Office, viz. Valencia, Aberdeen, Falmouth, and Kew. The second part contains monthly and yearly means of temperature, and also the actual extremes of observed temperature obtained from eye observations of maximum and minimum thermometers made at 117 stations in the British Isles. The means for the different stations are for periods varying from 15 to 30 years, and in the case of the Royal Observatory, Greenwich, for 60 years.

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REPORT ON THE WIND FORCE EXPERIMENTS ON H.M.S. *WORCESTER* AND AT STONENESS LIGHTHOUSE.

By W. H. DINES, B.A., Pres. Roy. Met. Soc., and
Capt. D. WILSON-BARKER, F.R.S.E., F.R.Met.Soc.

[Read May 21, 1902.]

THE experiments conducted on board the *Worcester* in connection with the exposure of anemometers were described in the Report of the Wind

FIG. 1.—Stoneness Lighthouse with Anemometer.

Force Committee read before the Society in November 1898 (*Quarterly Journal*, xxv. p. 1). At the wish of the Committee, these experiments have been continued, with the view of obtaining some knowledge of the

discrepancies which may exist between two anemometers erected in the same neighbourhood, but under different conditions of exposure.

The Stoneness Lighthouse lies opposite the *Worcester*, on the north bank of the river; its bearing from the ship is N. 34° W., and its distance is 817 yards; and the Corporation of the Trinity House have kindly permitted the erection of an anemometer on this lighthouse.

The exposure on board the *Worcester* has been fully described in the previous Report, and it seems unnecessary to repeat an account of it. The exposure on the lighthouse is particularly good, the only elevation higher than it occurring in the south-west to south-east quadrant. In both positions the North-east and North-west winds have a free passage over the river; the North-east winds coming for 1½ miles over the water, and the North-

FIG. 2.—Stoneness Lighthouse from H.M.S. *Worcester*.

west for 3 miles. The wind frequently blows steadily and strongly along both reaches. Strong winds often come, too, from the South-west, but are unsteady in direction and force; this is shown, both on the *Worcester* and at the lighthouse, by the swaying of the vanes. To the north of the lighthouse the ground is flat, and, as previously stated, the only point toward which the exposure is not an ideal one is the south. Under these circumstances the position seemed to be an especially favourable one for the purpose of comparison, and accordingly observations have been made throughout the winters of 1899, 1900, and 1901.

The anemometer on the *Worcester* is placed at the mizen-mast head, 125 ft. above the water-line; that on the lighthouse is 53 ft. 6 in. above the bank of the river, which is just awash at high spring tides.

The instruments were the same as those previously described, excepting that small spirit reservoirs have been arranged in connection with the glass tubes, from which the inevitable evaporation takes place instead of from the glass tubes. The plan has answered well, and the instruments have required but little attention; they have, however, been overhauled every now and then by Capt. Wilson-Barker.

The method of taking an observation was as follows. One observer was rowed over to the lighthouse, and, on reaching the platform where the instrument was placed, waved a handkerchief. This was plainly visible to the observer on the *Worcester*, and was the signal by which simultaneous readings were assured. The instruments were then re-set. Great care has been taken to ensure accuracy. The observations have been made by Capt. Wilson-Barker and Instructor May, sometimes one observer going to the lighthouse and sometimes the other. The instruments are exact facsimiles of each other, and although the distances from the head to the indicating tubes were not the same, an extra length of tube was used on the lighthouse, so that there might be an exact equality.

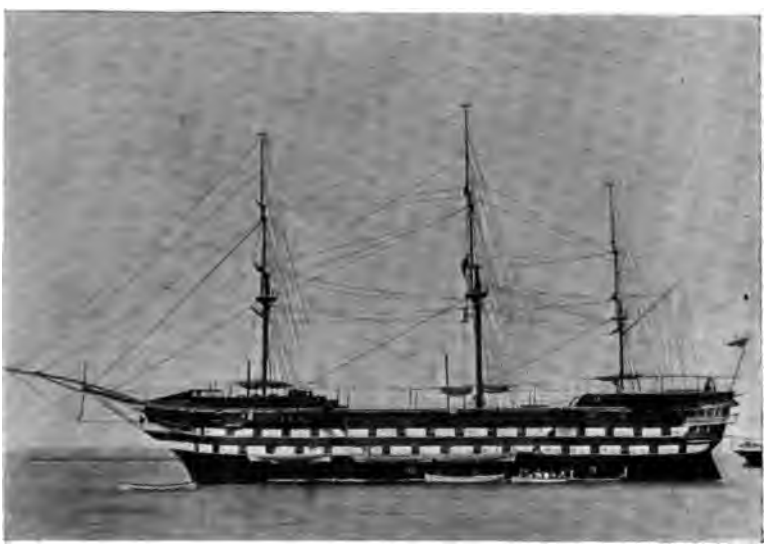


FIG. 3.—The Nautical Training College, H.M.S. *Worcester*, off Greenhithe, Kent.

Owing to the fact that each observation involved a boat journey of about a mile, and that observations were only made during term time, also that many observations have been omitted from the tables because they referred to winds below 10 miles per hour, the final averages are not based on as large a mass of figures as some might think desirable. The authors believe, however, that they are amply sufficient for the purpose, excepting in the case of South-east winds.

There are three separate values to be compared, and it may perhaps be convenient to repeat the particulars about them from the previous Report.

(1) Simultaneous readings of the damped tube. These may be taken as giving the mean velocity for the preceding five or ten minutes at each position. As might be expected, these values do not agree individually, variations amounting to 20 per cent between the simultaneous velocities in the two positions often occurring.

(2) The maxima given by the damped tubes in the two positions. These maxima show the highest velocity that has lasted for more than

one or two minutes since the instruments were last set. These also have often varied by 20 per cent between the two positions.

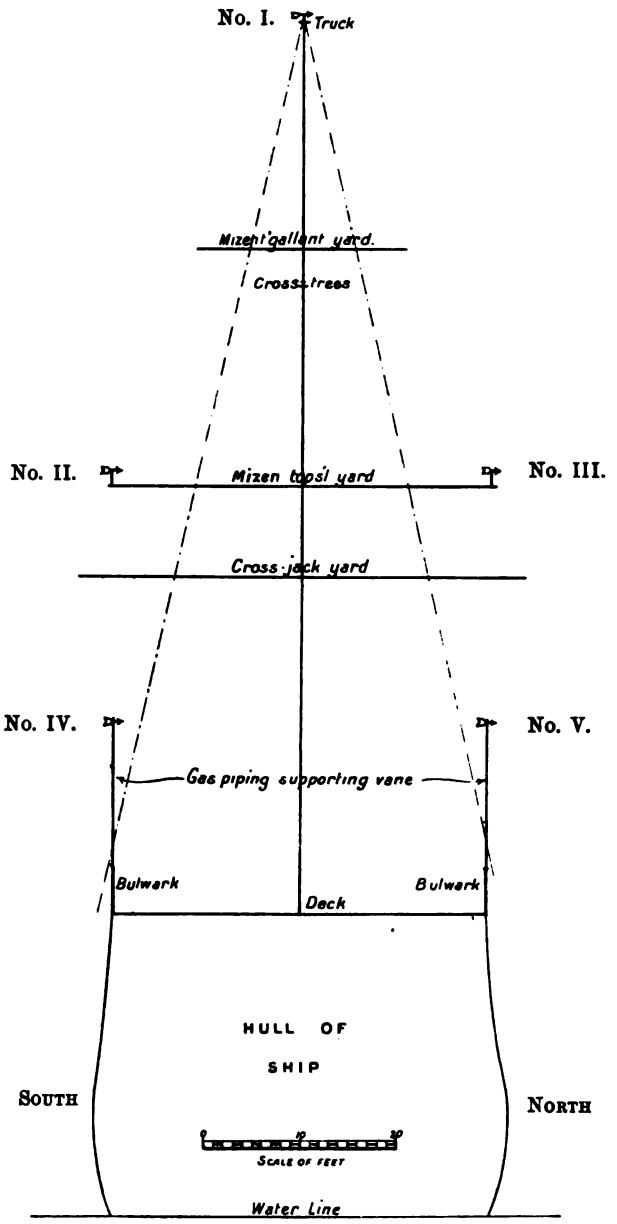
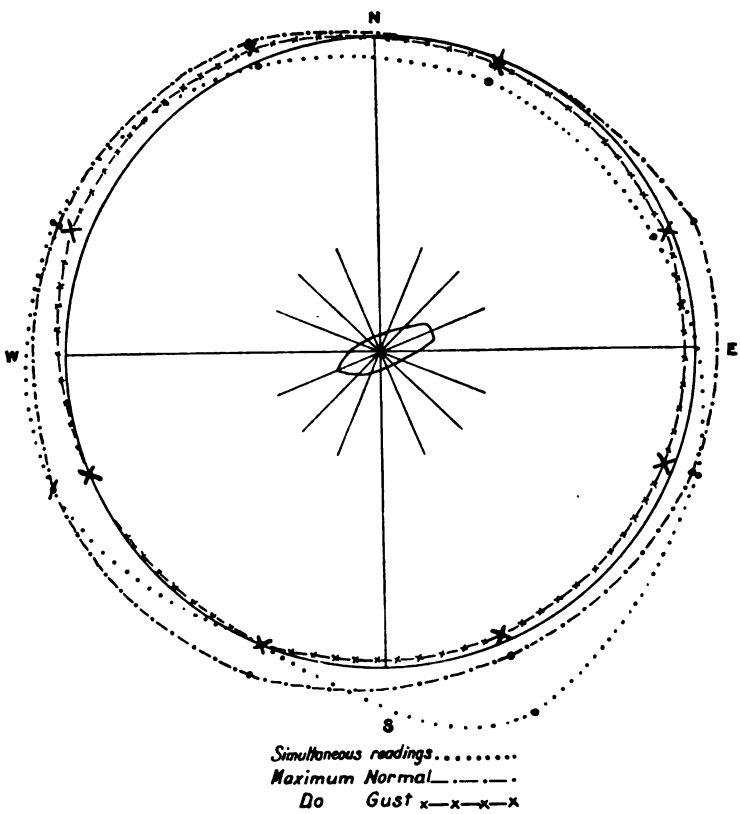


FIG. 4.—Section of Ship, viewed from astern.

(3) The maxima recorded in a gust of very brief duration (one or two seconds).

These values are far less discordant than either of the others when expressed as percentages.

The simultaneous observations do not show any high velocities, since landing at the lighthouse was hardly possible during a gale. The damped maxima often exceeded 30 miles per hour, but the highest recorded during the two winters was only 48, in a South-westerly gale on April 14, 1900, at the lighthouse. The highest velocity in a gust was 90 miles per hour on November 11, 1899, also at the lighthouse.



The continuous circle = 100.

FIG. 5.

The averages are given in the table on the following page, and are also shown graphically in Fig. 5.

The figures show the percentage that the wind at the lighthouse bears to that at the *Worcester* for eight separate directions. The observations are not numerous enough to make any further subdivision of direction desirable. Perhaps the only point calling for special comment is the 124 in the first column with South-south-east winds. There can be little doubt that this is an accidental discrepancy which would be eliminated had the South and South-east winds been more frequent.

The broad general result is that the lighthouse experiences steadier and stronger winds than the *Worcester*, the velocity being about 6 per cent greater, notwithstanding the fact that elevation is less than half; but that in both positions the extreme velocities reached in the gusts are about equal.

LIGHTHOUSE VALUES EXPRESSED AS PERCENTAGES OF THOSE ON THE *WORCESTER*.

Direction.	Simultaneous Readings.		Max. since last Reading.			
			Normal.		Gust.	
	Per Cent.	No. of Obs.	Per Cent.	No. of Obs.	Per Cent.	No. of Obs.
N. – N.E. by N.	92	9	100	17	98	17
N.E. – E. by N.	94	11	107	12	98	12
E. – S.E. by E.	108	8	106	12	96	12
S.E. – S. by E.	*124	4	104	6	97	6
S. – S.W. by S.	99	6	109	9	100	9
S.W. – W. by S.	112	13	112	20	100	20
W. – N.W. by W.	112	5	110	8	105	8
N.W. – N. by W.	98	8	107	15	104	15
Mean . . .	105		107		100	

It is also plain from the observations that the actual strength of the wind on the Thames in its lower reaches is not great when compared with that which frequently prevails on the coast, or at all events on the Western Coast.

APPENDIX.

PROCEEDINGS OF THE WIND FORCE COMMITTEE, 1885-1902.

FIRST MEETING, *June* 30, 1885—Mr. SCOTT, President, in the Chair.

The Resolution of the Council appointing the Committee was read as follows:—

"That a Committee be appointed to investigate the relation between Beaufort's Notation of Wind Force and the equivalent velocity in miles per hour, as well as the corresponding pressure in pounds per square foot, for each grade of the scale; to inquire whether any existing scale can be adopted or modified, and if not, to determine such equivalents as can be recommended for general and international use; also that the Committee be requested to report on the best mode available for the attainment of a satisfactory solution of the entire question of Wind Force."

The Committee was constituted as follows. Mr. E. D. Archibald, Mr. G. Chatterton, Mr. C. Harding, and Mr. J. K. Laughton, with the officers of the Society. A letter was read from Mr. Chatterton, stating that Mr. (now Sir Benjamin) Baker had offered to place the results of the Forth Bridge experiments at the disposal of the Committee.

Mr. C. Harding was requested to prepare a scheme for the investigation of the relation between Beaufort's Notation and the equivalent velocity in miles per hour, and to submit the same for consideration at next meeting.

SECOND MEETING, *July* 7, 1885—Mr. SCOTT, President, in the Chair.

Mr. C. Harding read a statement which he had drawn up, and submitted the following subjects for consideration :—

(1) The desirability of collecting copies of all existing wind scales, and that a thorough examination of these be made, sifting out those that are worthless, and preserving those promising to contain valuable and reliable data.

(2) That a further examination be made of velocities by anemometer in comparison with entries of Beaufort's Notation in the registers of lightships and lighthouses.

The anemometer stations and lights recommended are—

Anemometer	Yarmouth	Lightship—	Newarp, Cuckle, St. Nicholas Gat, Corton, Leman and Ower, and Galloper.
,,	Holyhead	,,	Skerries, South Stack, and Carnarvon Bay.
,,	Valencia	,,	Tearaght, Skellig, and Calf Rock.
,,	Falmouth	,,	Wolf, Lizard, St. Anthony's Point, and Eddystone.

The comparison to be limited to the year 1881.

(3) That a Robinson's Cup Anemometer and an Osler's Pressure-Plate Anemometer be run side by side on a locomotive.

(4) That the Forth Bridge observations be used by the Committee in the inquiry, as affording valuable data for the relation existing between wind pressures over widely different areas.

Recommendation No. 2 was adopted, and it was resolved that application be made to the Trinity House for the loan of the logs of the lights as required.

Mr. Chatterton undertook to make the tabulation of the Trinity House data.

Recommendation No. 3. The President was requested to communicate with Mr. F. W. Webb, and inquire if the Committee could obtain the use of an engine on the London and North-Western Railway for making experiments.

Resolution No. 4 was adopted.

THIRD MEETING, *July* 21, 1885—Mr. SCOTT, President, in the Chair.

Letter read from Mr. F. W. Webb, stating that the Directors of the London and North-Western Railway were unable to grant the use of an engine on a side line for experimental purposes.

It was suggested that Mr. Chatterton should make inquiries as to whether the use of an engine could be obtained on any other line.

It was decided to ask Mr. Laughton to discuss the Forth Bridge observations which Sir B. Baker was willing to place at the disposal of the Committee.

FOURTH MEETING, *November* 3, 1885—Mr. SCOTT, President, in the Chair.

Mr. Chatterton not being present to submit his Report on the discussion of the lightship logs, the Committee adjourned.

FIFTH MEETING, *February* 25, 1886—Mr. ELLIS, President, in the Chair.

Mr. Chatterton explained by diagrams the results he had arrived at by comparing the Yarmouth anemograms with the logs of six lightships to the east of Yarmouth.

Table not reproduced here.

Mr. Chatterton undertook to make a comparison of the Holyhead anemograms with the logs of the South Stack Lighthouse and of the Carnarvon Bay Lightship.

Mr. Chatterton stated that probably facilities would be afforded on the Great Northern Railway for running a Robinson Anemometer and a pressure-plate on a locomotive.

It was resolved that application be made to the Kew Committee for the loan of the Standard Anemometer, if it should be free when the experiments are to be made.

SIXTH MEETING, *May* 4, 1886—Mr. ELLIS, President, in the Chair.

Mr. Chatterton submitted a table giving the results of his comparison of the South Stack Lighthouse and the Carnarvon Bay Lightship with the Holyhead anemometer.

Mr. W. F. Stanley was requested to join the Committee.

SEVENTH MEETING, *June* 16, 1886—Mr. ELLIS, President, in the Chair.

Letter was read from Capt. H. Toynbee, enclosing some results from an anemometer run on board ship by Capt. A. S. Thomson, F.R.Met.Soc.

A MEETING OF A SUB-COMMITTEE WAS HELD *July* 21, 1886—
Mr. CHATTERTON in the Chair.

The subject of testing anemometers on locomotives was somewhat fully discussed.

EIGHTH MEETING, *December* 7, 1886—Mr. ELLIS, President, in the Chair.

Mr. Chatterton submitted a report on the comparison between the Eddystone and the Wolf Rock Lighthouses and the Falmouth anemometer.

He was requested to prepare a report on the work already done.

Report printed, *Quarterly Journal*, vol. xiii. pp. 215-218.

NINTH MEETING, *April* 5, 1887—Mr. ELLIS, President, in the Chair.

Letter read from Mr. R. H. Curtis, submitting a plan for the investigation of the relation between the velocity of the wind and the rate of motion of the cups of velocity anemometers.

Mr. Dines gave a description of his whirling machine for testing anemometers.

TENTH MEETING, *December* 16, 1887—Mr. ELLIS, President, in the Chair.

Mr. Chatterton suggested that a digest should be made of all published papers bearing on the question of anemometry since the introduction of Robinson's Cup Anemometer.

Mr. Dines was authorised to hire a steam-engine for the sum of £6, for the purpose of testing anemometers on his whirling apparatus.

ELEVENTH MEETING, *April* 10, 1888—Dr. MARCET, President, in the Chair.

Messrs. Dines and Whipple submitted a Report on the results obtained by the use of the steam-engine on the whirling apparatus.

Report printed, *Quarterly Journal*, vol. xiv. pp. 253-259.

An additional grant of £9 was made for the continued hire of the steam-engine.

TWELFTH MEETING, *November* 12, 1889—Dr. MARCET, President, in the Chair.

Mr. Dines read a Report on the Factor of the Kew pattern Robinson Anemometer.

Report printed, *Quarterly Journal*, vol. xvi. pp. 26-36, with Appendix on "Literature of Anemometry."

THIRTEENTH MEETING, *December* 3, 1889—Dr. MARCET, President,
in the Chair.

The Report above mentioned was reconsidered, and it was resolved to illustrate it for the *Quarterly Journal*.

FOURTEENTH MEETING, *May* 21, 1890—Mr. LATHAM, President, in the Chair.

The following Resolutions were adopted :—

(1) That in the opinion of this Committee simultaneous observations shall be carried out with the following instruments—Robinson, Richard, and Helicoid Anemometers, Air Meters, Pressure Plates, Tube Anemometers, and Bridled Anemometers.

(2) That the foregoing Resolution, if approved by the Council, be forwarded to Mr. Dines, to assist him in an application for a grant from the Meteorological Council.

(3) The Committee report that until the foregoing experiments have been made, they are not in a position to advise the Council on the subject referred to them.

A Report by Mr. Dines on the result of the experiments suggested at the Fourteenth Meeting was read before the Society, April 20, 1892.

Printed, *Quarterly Journal*, vol. xviii. pp. 165-183.

FIFTEENTH MEETING, *May* 3, 1892—Dr. WILLIAMS, President, in the Chair.

Mr. Dines' Report, above mentioned, was reconsidered, and thanks were voted to him for it.

Messrs. Dines and Munro were requested to prepare drawings of a tube anemometer, fitted for registering pressure and velocity.

SIXTEENTH MEETING, *May* 31, 1892—Dr. WILLIAMS, President, in the Chair.

Mr. Munro exhibited the drawings of Dines' Tube Anemometer with recording apparatus.

It was resolved to request Mr. Dines and Mr. Munro to prepare a written description, and to forward the same, along with the drawing, to the Meteorological Council.

It was also decided that a letter be written to the Meteorological Council stating that the above instrument is the recommendation of the Wind Force Committee.

SEVENTEENTH MEETING, *December* 13, 1892—Dr. WILLIAMS, President, in the Chair.

On the motion of Mr. Laughton it was resolved—

"That the Committee are of opinion that the results of Mr. Dines' experiments have confirmed the evidence that the use of the factor 3 for the Robinson Anemometer, known as the Kew pattern, the dimensions of which are

Distance of centre of cups from centre of axle	24 ins.
Diameter of cups	9 ins.

is incorrect, and recommend the adoption of the factor 2·1 for that pattern.

"As regards the small-sized anemometers, sometimes called Robinson's Anemometers, the Committee find that they have been constructed of such various sizes and proportions that no general factor can be assigned.

"The factor is probably higher than that for the Kew pattern, but may be anything between 2·1 and 3. Nothing but the verification of each individual instrument can enable its factor to be determined."

EIGHTEENTH MEETING, *May* 1, 1894—Mr. INWARDS, President, in the Chair.

Mr. Dines requested the Committee to consider the possibility of getting anemometers erected at five or ten exposed coast stations or rock lighthouses, by which a reliable comparison between the velocity and the Beaufort Scale might be deduced.

After some consultation it was resolved that a Committee consisting of Mr. Chamberlain, Mr. Dines, and Mr. Scott be appointed to communicate with Mr. Mathews, Engineer to the Trinity House, and with other parties, if found desirable, as to the possibility of carrying such a scheme into effect.

NINETEENTH MEETING, *November* 26, 1895—Mr. EDWARDS, President, in the Chair.

Mr. Chamberlain reported that he, together with Mr. Dines and Mr. Scott, had seen Mr. Mathews, the Engineer to the Trinity House, as to the possibility of getting some anemometers erected on several lighthouses.

As the result of the interview and of further correspondence, it seemed impossible for anything of the kind to be done, as the difficulties in the way of erecting anemometers on the lighthouses are so great.

The Committee decided not to proceed further in the matter.

Mr. Curtis undertook to discuss some of the anemometrical records now in the Meteorological Office, with the view of comparing the estimated and registered wind force. It was resolved that application be made to the Meteorological Council for permission for Mr. Curtis to have access to the records in the Meteorological Office.

TWENTIETH MEETING, *May* 5, 1896—Mr. MAWLEY, President, in the Chair.

The Committee considered the question of carrying out experiments on wind force at different altitudes.

Capt. Wilson-Barker submitted a proposal for experiments to be carried out on board H.M.S. *Worcester*, off Greenhithe.

After some conversation the further consideration of the matter was postponed until the next Meeting.

TWENTY-FIRST MEETING, *June* 17, 1896—Mr. MAWLEY, President, in the Chair.

The question of carrying out experiments on wind force at different altitudes on board H.M.S. *Worcester* off Greenhithe was further considered.

It was resolved that the Council be requested to place at the disposal of the Committee a sum of £35 from the Research Fund, to be expended, under the direction of Mr. Dines and Capt. Wilson-Barker, in the purchase of anemometers and the expenses of fitting them up at different elevations near Greenhithe.

TWENTY-SECOND MEETING, *November* 3, 1896—Mr. MAWLEY, President, in the Chair.

Mr. Curtis submitted a Report on "An Attempt to determine the Velocity Equivalents of Wind Forces estimated by Beaufort's Scale."

This was considered and adopted, and it was resolved to recommend it to be read before the Society at the December Meeting.

Printed, *Quarterly Journal*, vol. xxiii. pp. 24-61.

TWENTY-THIRD MEETING, *May* 24, 1898—Mr. BAYARD, President, in the Chair.

Mr. Dines read an *ad interim* Report on the experiments on Wind Force at different elevations on board H.M.S. *Worcester*.

Mr. Dines and Capt. Wilson-Barker were requested to complete the Report and to bring it up in the course of the next Session.

TWENTY-FOURTH MEETING, *November* 1, 1898—Mr. BAYARD, President, in the Chair.

Mr. Dines and Capt. Wilson-Barker submitted their "Report on Experiments upon the Exposure of Anemometers at Different Elevations," which was considered

and adopted, and recommended for reading before the Society at the Meeting on November 10.

Printed, *Quarterly Journal*, vol. xxv. pp. 1-19.

TWENTY-FIFTH MEETING, *February* 15, 1899—Mr. BAYARD, President, in the Chair.

The Committee were of opinion that simultaneous observations of Wind Force should be made on board H.M.S. *Worcester* and on shore.

It was resolved that, with the permission of the Trinity House, a pressure-tube anemometer be erected on the lighthouse at Stoneness Point, about 800 yards from the ship, on the north side of the river.

TWENTY-SIXTH MEETING, *October* 31, 1899—Mr. BAYARD, President, in the Chair.

Capt. Wilson-Barker reported that the observations at Stoneness Point had been in operation about a fortnight.

A letter was read from Mr. C. L. Brook of Meltham as regards the possible erection of an anemometer on the Victoria Jubilee Tower at Huddersfield.

TWENTY-SEVENTH MEETING, *March* 4, 1902—Mr. DINES, President, in the Chair.

Capt. Wilson-Barker submitted a Report on the Wind Observations on H.M.S. *Worcester* and at Stoneness Point Lighthouse. It was decided that the Report should be amplified and the observations given *in extenso*.

Mr. C. Harding suggested that the Committee should make a definite pronouncement on the Beaufort Scale and the equivalent velocities.

After some conversation on the scope of the inquiry entrusted to the Committee, Mr. Scott undertook to prepare a digest of the proceedings of the Committee from its appointment in 1885 to the present time. It was thought that this digest should be added to the Report of the Committee.

TWENTY-EIGHTH MEETING, *April* 4, 1902—Mr. DINES, President, in the Chair.

Capt. Wilson-Barker read an extended Report on the Wind Force Experiments on H.M.S. *Worcester* and at Stoneness Lighthouse, drawn up by Mr. Dines and himself, which was adopted and recommended to be read at a Meeting of the Society.

Mr. Scott read a summary of the Proceedings of the Committee from its appointment in 1885 to the present time. It was resolved that this form an Appendix to the above Report.

After some conversation on the question of the Factor for the Robinson Anemometer it was resolved to recommend the Council to rescind the Resolution of December 13, 1892, as to the factor 2·1 for correcting the Robinson Anemometer (Kew pattern), and to adopt the value 2·2, which further experience shows to be the more accurate.

DISCUSSION.

Mr. R. INWARDS (Chairman *pro tem.*) said it could be seen from the Appendix that the Committee had done excellent work over a course of many years, as shown by the various reports it had printed, and its deliberations had rendered essential service to the Society and to science generally. All ought to be grateful for its arduous and protracted investigations.

Mr. W. H. DINES said the correctness of the factor 2·20 for the Kew pattern Robinson anemometer was a question that depended upon the correctness of the records of the tube anemometer. Adopting this factor, the two instruments agreed at velocities over ten miles per hour, and inasmuch as the method by which the tube anemometer was originally calibrated upon the Hersham whirling machine was one that admitted of great accuracy, he thought there was good ground for adopting 2·20 instead of 2·10. Perhaps it was a question as to what was meant by wind velocity. Was it to be based on the length of the actual path followed by an air particle, or on the length measured as a straight line between the two ends of this undoubtedly irregular path? These two might well differ by five per cent.

Mr. BALDWIN LATHAM remarked that since the first appointment of the Committee an enormous advance had been made in the study of anemometry. This, he thought, was largely due to Mr. Dines and his invention of the pressure-tube anemometer. That alone would compensate for any time and trouble spent over the Committee.

Mr. J. HOPKINSON said that of all non-instrumental meteorological observations, the estimation of the force of the wind was the most puzzling, chiefly owing to the maximum limit of Beaufort's scale not being experienced in this country. During ten years' observations at Watford and twelve at St. Albans he had twice recorded force 7, and 6 several times, the daily average being 1·8 at both places. He described the effect of the wind upon himself when cycling that morning, a head wind retarding his usual pace about 25 per cent, and a rear wind accelerating it 20 per cent. He estimated the force of the wind as 3.

Mr. G. B. WETHERALL thought that the average wind force, from his observations in the county of Worcester for the last twenty-five years, was about 1·6.

Mr. R. H. CURTIS thought it might be desirable to explain a little more fully the particular object the Committee had in view in comparing the indications of an anemometer at Stoneness Point with one at the masthead of the *Worcester*. The original experiments, which were discussed in the paper read in 1898, were made on board the ship at different elevations above the river level, and they showed that, whilst the hull of the vessel had an unmistakable influence upon the indications of the anemometers exposed at the lower heights, there was also reason to think that, even at the height of the masthead, the full strength of the wind was not felt whenever it blew from the direction of the relatively high land close at hand on the southern shore of the river. It was to test this supposition more thoroughly, and, if possible, to get some notion of the extent to which higher land might be expected to influence the record of an anemometer, that these further experiments were undertaken; and, as the site at Stoneness Point was considered to be fully exposed to winds from all points of the compass, and was at the same time sufficiently near to the *Worcester*, it was thought to be a very satisfactory one for the purpose. The results appear to confirm the suspicion that the land does influence the record of the anemometer at the masthead, 120 feet above the water level. The observations made simultaneously at the ship and at the lighthouse give slightly lower forces at the lighthouse for winds from North-north-west through North to East by North, which is the most open exposure for the ship; but higher forces for other points, and especially for points just to the east of south, which is the direction in which the land is highest. This conclusion is very important, because it shows once more the necessity for securing a perfectly unbiassed exposure for an anemometer if it is desired to obtain from it data which will represent the true wind force of the district in which the instrument is erected.

THE CORNISH DUST-FALL OF JANUARY 1902.

By HUGH ROBERT MILL, D.Sc., LL.D., F.R.Met.Soc.

[Read May 21, 1902.]

THE fall of dust with rain is a phenomenon so thoroughly established that it has lost the interest of novelty, and the discussion of an instance of its occurrence is only justified when the fall is unusually wide-spread, or has been exceptionally carefully observed. Since the date of the Krakatoa eruption in 1883, when the volcanic dust thrown into the air made itself apparent for many months all over the world in a long series of brilliant sunsets, the most remarkable instance of far-travelled dust is that which occurred in March 1901. In Italy the rain fell so thickly charged with red sand on March 11 of that year that the peasants took it for blood, and were panic-stricken by the fearful portent. For three days the dust-cloud travelled northward over central Europe, substantial traces falling as far north as the Danish Islands on the 13th; and a few instances in which it reached parts of England and Scotland on the same day have been recorded.[1] The whole phenomenon has been critically studied by Professors Hellmann and Meinardus, whose monograph entitled "Der grosse Staubfall vom 9 bis 12 März 1901"[2] contains much valuable information on the movements of the atmosphere during the period, in its higher strata as well as at sea-level.

When the West of England newspapers of January 24, 1902, announced falls of pink snow and muddy rain in several parts of Cornwall and South Wales, it seemed possible that fresh light might be thrown on what is at present the chief object of progressive meteorology—the movements of the upper air. In reply to inquiries, I received communications from a number of friendly correspondents in Wales and the west of England, and published a short preliminary article, summarising the information, in *Symons's Meteorological Magazine* for February. This led to a largely increased correspondence, thanks to the notice taken by the daily press, and the accumulation of a considerable mass of data which it seems desirable to place on record, even although the conclusions which can be drawn may not much advance the theoretical question.

Looking first at the distribution of the fall of dust with rain, irrespective of its nature or amount, we find that the phenomenon was reported from 75 different places in the south-west of England and Wales. With the exception of an isolated observation at Dolgelly in North Wales, these were all to the south of a line joining Milford Haven and Chepstow, and all of them west of the meridian of Bath; or, to put it slightly more widely, south of latitude 52° N., and west of longitude 2° W. It was natural to assume at first, when 34 cases were reported from different parts of this area, that the dust-fall had sprinkled the whole intervening surface; but the special inquiries sent out to observers living in the places whence no reports had been received have shown conclusively that the fall was discontinuous. As it is proverbially hard to prove a negative, we must endeavour to make this point clear at the outset. The

[1] At Great Malvern, Scarborough, and Dumfries.

[2] *Abhandlungen des königlich preussischen Meteorologischen Instituts*, Bd. II. No. 1.

fact that no one had sent a letter to the papers, or that no one had spontaneously written to inform me that a fall of dust had been observed, was not considered to be evidence either positive or negative. It was considered evidence that no dust had fallen when a letter was received from some careful and responsible observer, giving a negative reply as the result of his special inquiries in the neighbourhood where he lived. If such an observer had noticed nothing unusual when measuring the rainfall on the days in question, and had heard of nothing unusual on inquiring amongst his neighbours, one may safely consider that any fall of dust which might have taken place in his vicinity must have been of negligible amount. The report of the falls of dust in Cornwall had spread everywhere, thanks to the intelligent interest taken in natural phenomena by the local press; and long before the special inquiries reached the clergyman, medical practitioner, schoolmaster, or gardener who kept the rain records, the whole subject had been talked over by the villagers, and if a washing spread out to dry had been spoiled by muddy splashes, that fact was not forgotten. Again, any appearance of dust or mud on the glasses of the lantern of a lighthouse or light-vessel could not escape attention, and if nothing unusual was entered in the log, it may be confidently assumed, from the general efficiency of the lightkeepers under the Trinity House, that nothing noticeable in the way of a dust-fall had taken place.

Every instance of a trustworthy observer reporting no appearance of dust is entered on the map, Fig. 1, as a ring, while each reported dust-fall is shown as a solid dot. From this map it is clear that five separate areas were visited by the dust between January 21 and 23.

The largest or Cornwall area measures nearly 80 miles in length, and averages about 20 miles in breadth, considering the land alone. It includes the whole of Cornwall except a strip of the north-west coast from Wadebridge to Bude, and also includes a narrow strip of South Devon from near Plympton to beyond Coryton. This area comprises about 1400 square miles of land; but it extends seaward to include the Eddystone Lighthouse, the Wolf Rock Light-vessel, south of Land's End, the Seven Stones Light-vessel, west of Land's End, and probably the Scilly Isles. It seems, however, to have been sharply bounded on the east by the slopes of Dartmoor.

The North Devon area was very small, and is indicated by three stations only—at Hartland Point Lighthouse, Melbury Moor, and Black Torrington; but it is clearly separated from the Cornish area by three very definite blanks at Bude, Holsworthy, and Okehampton; and its possible extension to the north-eastward is limited by blanks at Barnstaple, Umberleigh, and Burrington. This area measures about 20 miles in length, and may amount to about 150 square miles.

The Milford Haven area was probably also very small, and is indicated by three stations, one of them being the Smalls Lighthouse (off the coast), the other two on the shores of Milford Haven. As none of the neighbouring lighthouses reported the dust, we may assume this area not to have affected more than perhaps 50 square miles of land; and as the three stations which recorded a dust-fall give a somewhat uncertain report, even this small estimate may be excessive.

The Somerset area was somewhat irregular, and extended at one

point into Gloucestershire. It may be taken as measuring 30 miles from north to south, and 15 miles in the extreme from east to west, with an area of about 260 square miles.

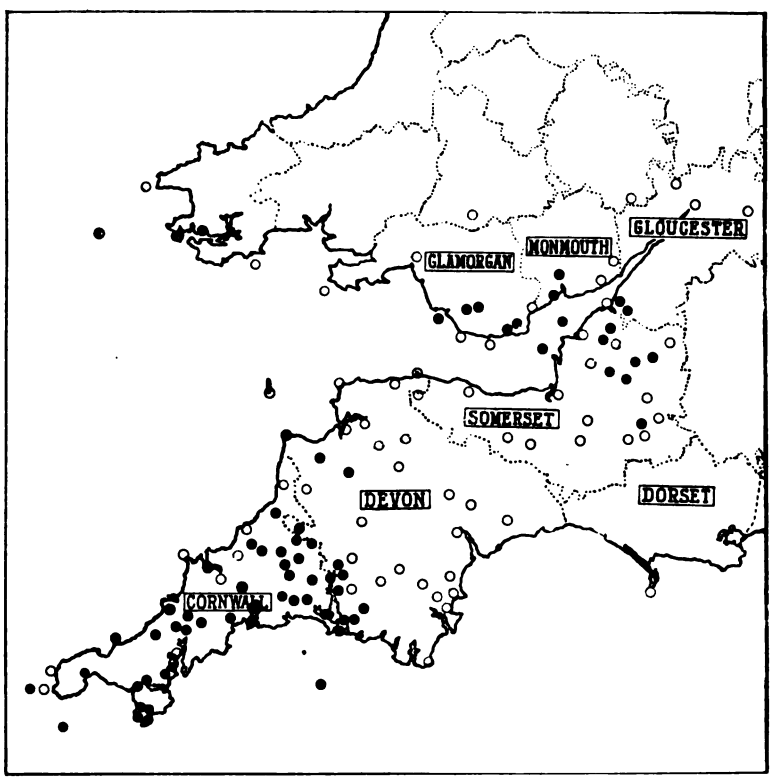


FIG. 1.—The Dust-fall of January 1902.
(The dark circles mark stations where a fall of dust was observed ; the rings indicate places where no dust was noticed.)

The South Wales area, including the light-vessels in the Bristol Channel, which are classed in the county of Somerset, was also irregular in outline. It had an extreme length of 40 miles, and measured probably 540 square miles, of which 340 were land.

The solitary fall reported at Dolgelly may be left out of account, and it would seem as if the area of land covered, however thinly, by the dust was :—

Cornwall area	1400	square miles
North Devon area	150	,,
Milford Haven area	50	,,
Somerset area	260	,,
South Wales area	340	,,
Total area of land	2200	,,

It is sufficient at present to point out that the dust was detected at most of the light-vessels lying a considerable distance off the land, and that the only marked influence of the configuration of the ground on its

distribution is its tendency to occur on low rather than high ground. Thus the Mendip hills, Dartmoor, Exmoor, and the Welsh mountains appear to have been untouched; but on the other hand Bodmin moor was plentifully sprinkled, and the comparative paucity of observations on the high ground makes the negative proof there less satisfactory than on the coasts or the more thickly peopled plains.

The following lists give the names of the places where the dust was observed, the authorities responsible for the statement, and remarks giving any definite information as to date, time, and wind.

Stations reporting Dust, January 1902.

Devonshire.

Plymouth Breakwater—Sunrise on 23rd; W. to W.N.W.—*Trinity House.*
Plymouth Sound—Morning of 23rd—*C. King.*
Brixton—No date—*Western Morning News.*
Hooe—Morning of 23rd—*J. Little.*
Plymouth, Mill Bay—Between sunset of 23rd and sunrise of 24th—*Trinity House.*
Plympton—"No doubt on 22nd"—*J. Brooking Rowe.*
Lee Moor—"No doubt on 22nd"—*J. Brooking Rowe.*
Bere Alston—On 22nd; a dust-fog on 23rd—*Western Morning News.*
Buckland Monachorum—No date—*Western Morning News.*
Lifton—No date—*Mrs. Hammond.*
Coryton—No date—*T. M. Symons.*
N. Petherwyn—No date—*C. U. Tripp.*
Black Torrington—No date—*Western Morning News.*
Melbury Moor—Between evening of 21st and morning of 22nd—*Baldwin Latham.*
Hartland Point Lighthouse—Between night of 22nd and morning of 23rd; S.S.W. to S.—*Trinity House.*

Cornwall

Scilly, Tresco Abbey—Night of 21st; W.—*T. A. Dorrien-Smith.*
Lizard Lighthouse—No date; S.W.—*Trinity House.*
Lizard—About 21st or 22nd—*Western Morning News.*
Cury—No date—*Western Morning News.*
Ruan Minor—No date—*Western Morning News.*
Wolf Rock Lighthouse—Morning of 23rd; W.—*Trinity House.*
Seven Stones Light-vessel—Morning of 23rd; W. by S.—*Trinity House.*
Helston—No date—*Western Morning News.*
Wendron—No date—*Western Morning News.*
Penzance—No date—*C. H. Benn.*
Mawnan, near Falmouth—On 22nd—*Western Morning News.*
Eddystone Lighthouse—On 22nd before daybreak; W. by S.—*Trinity House.*
Scorrier—Afternoon of 22nd; W.—*E. H. Williams.*
St. Erme, Truro—In rain falling on night of 22nd—*Western Morning News.*
Perranporth—On 21st, and again on 22nd and 23rd—*E. Veale.*
,, Seen on morning of 22nd—*Joseph Turner.*
St. Agnes—No date—*Western Morning News.*
Perranzabuloe—On 22nd—*Joseph Turner.*
St. Austell—Date uncertain—*J. M. Coon.*
St. Austell, Reten—On 22nd—*Joseph Turner.*
Fowey—Seen on 23rd—*J. M. Clemens.*
Lostwithiel—No date—*Western Morning News.*
Menheniot—No date—*Western Morning News.*
Bodmin—About the 22nd—*Western Morning News.*
Callington—No date—*Western Morning News.*
Calstock—No date—*Western Morning News.*
Gunnislake, St. Ann's Chapel—No date—*Western Morning News.*
,, Albaston—No date—*Western Morning News.*
Quethiock—Night of 22nd or early morning of 23rd—*Rev. J. Augustus Wix.*
Padstow—"About 21st-23rd"—*C. U. Tripp.*
Bolventor—No date—*C. U. Tripp.*
North Hill—No date—*C. U. Tripp.*
Five Lanes—Seen on 22nd—*C. U. Tripp.*

ALTARNON—Seen on 23rd—*C. U. Tripp.*
LEWANNICK—Early on 21st; again on 22nd—*C. U. Tripp.*
TREWEN—No date—*C. U. Tripp.*
LANEAST—No date—*C. U. Tripp.*
ST. CLETHER—No date—*C. U. Tripp.*
DAVIDSTOW—At noon on 21st—*C. U. Tripp.*
EGLOSKERRY—No date—*Western Morning News.*
JACOBSTOW—No date—*C. U. Tripp.*

SOMERSET:

CASTLE CARY—"Before the 28th"—*Miss Agnes Fry.*
CHEWTON PRIORY—After the 22nd—*Earl Waldegrave.*
EAST HARPTREE—On the 23rd—*W. W. Kettlewell.*
HALLATROW—Between 7 and 8 a.m. on 23rd—*C. A. Kemble.*
FLAX BOURTON—No date—*Miss Agnes Fry.*
FAILAND—About 7 a m., probably on 22nd—*Miss Agnes Fry.*
FLATHOLM LIGHTHOUSE—On 22nd, about 5 p.m.; W.N.W.—*Trinity House.*
ENGLISH AND WELSH GROUNDS LIGHT-VESSEL—On 22nd, between 9.30 p.m. and midnight; W. by S.—*Trinity House.*

GLOUCESTER.

HENBURY, LAURENCE WESTON—7 a.m. on 23rd—*Bristol Times and Mirror.*
HENBURY HOUSE—7 a.m. on 23rd—*Bristol Times and Mirror.*

MONMOUTH.

WEST USK LIGHTHOUSE—On 23rd, between noon and sunset—*Trinity House.*
CAERLEON, LLANFRECHFA GRANGE—No date—*F. J. Mitchell.*

GLAMORGAN.

BARRY—Morning of 23rd or night of 22nd; W.N W —*E. W. Waite.*
SCARWEATHER LIGHT-VESSEL—No date—*Trinity House.*
BRIDGEND, MERTHYR MAUR—No date—*T. Thomas.*
PENCOED—Seen on 24th—*Western Mail.*

PEMBROKE.

SMALLS LIGHTHOUSE—On night of 15th—*Trinity House.*
MILFORD, ST. ANN'S LIGHTHOUSE—No date—*Trinity House.*
GREAT CASTLE HEAD LIGHTHOUSE—On 22nd, at sunrise—*Trinity House.*

MERIONETH.

DOLGELLY—Morning of 23rd—*A Correspondent.*

In cases where "No date" appears there is every reason to believe that the fall of dust was observed between the 21st and 23rd; the newspaper reports quoted were all published before the end of January.

No Dust-fall observed in January 1902.

DORSET.

PORTLAND—*Rev. W. R. Waugh.*
PORTLAND BILL—*Trinity House.*

DEVON.

START POINT—*Trinity House.*
DARTMOOR—*F. Howarth.*
PAIGNTON—*A. Chandler.*
TORQUAY—*W. G. Aspland.*
NEWTON ABBOT—*W. G. Aspland.*
WHITCHURCH, near TAVISTOCK—*E. E. Glyde.*
YELVERTON—*Dr. H. J. S. Liddell.*
ASHBURTON—*Fabyan Amery.*
PRINCETOWN—*Royal Meteorological Society.*
EXETER—*W. B. Heberden, C.B.*, and *A. R. Allinson.*
OKEHAMPTON AND NORTH DEVON—*H. Green.*
HONITON—*Major H. W. M. Sherwell.*
HOLSWORTHY—*C. U. Tripp.*
CULLOMPTON—*T. Turner.*
TIVERTON—*Miss Gill.*
BURRINGTON—*C. U. Tripp.*
UMBERLEIGH—*C. U. Tripp.*
BIDEFORD—*Trinity House.*
SOUTH MOLTON—*Dr. Hatherley.*
BARNSTAPLE AND NORTH DEVON—*T. Wainwright.*
LUNDY ISLAND—*Trinity House.*
BULL POINT—*Trinity House.*
MARTINHOE—*Rev. R. W. Oldham.*
LYNMOUTH—*J. H. Mead-Briggs.*
EXMOOR—*A. L. Ford.*
FORELAND—*Trinity House.*

CORNWALL.

ST. AGNES, SCILLY—*Trinity House.*
ROUND ISLAND, SCILLY—*Trinity House.*
BISHOP ROCK, SCILLY—*Trinity House.*
LONGSHIPS LIGHT-VESSEL—*Trinity House.*
PENDEEN—*Trinity House.*
FALMOUTH HARBOUR—*Trinity House.*
WADEBRIDGE—*C. U. Tripp.*
TREVOSE HEAD—*Trinity House.*
CAMELFORD—*C. U. Tripp.*
BOSCASTLE—*C. U. Tripp.*
BUDE—*J. Arthur.*

SOMERSET.

ILCHESTER—*Miss Agnes Fry.*
TAUNTON—*A. Eastwood* and *A. T. Coles.*
MILVERTON—*Miss F. E. Bere.*
NORTH CADBURY—*Rev. H. A. Boys.*
GLASTONBURY—*R. Neville Grenville.*
STREET—*W. T. Clark.*
BRUTON—*Rev. D. E. Norton.*
BURNHAM—*Trinity House.*
SHEPTON MALLET—*F. H. Berryman.*
DUNSTER, AND DISTRICT—*Rev. Prebendary Hancock* and *Rev. J. Utter Todd.*
NORDRACH-ON-MENDIP—*Dr. R. Thurnam.*
BATH—*Dr. W. H. Symons.*
CLEVEDON—*Eustace Button.*

GLOUCESTER.

AVONMOUTH—*Trinity House.*
COTSWOLD SANATORIUM—*C. Braine Hartnell.*
CHELTENHAM AND DISTRICT—*R. Tyrer* and *E. D. Marten.*
FAIRFORD, HATHEROP—*Rev. R. P. Davies.*

HEREFORD.

ROSS—*H. Southall.*
LEDBURY—*Spencer H. Bickham.*

MONMOUTH.

PORTSKEWETT, SUDBROOK—*W. K. Lawrence.*
CHEPSTOW, SHIRENEWTON HALL—*H. L. P. Low.*

GLAMORGAN.

BREAKSEA LIGHT-VESSEL—*Trinity House.*
NASH POINT—*Trinity House.*
CARDIFF—*A. Mee.*
HELWICK LIGHT-VESSEL—*Trinity House.*
NEATH—*Major E. Ll. Green.*

PEMBROKE.

CALDY ISLAND—*Trinity House.*
SOUTH BISHOP—*Trinity House.*

BRECON.

BRECON MOUNTAINS—*J. S. Masterman.*

CARMARTHEN.

CARMARTHEN BAY LIGHT-VESSEL—*Trinity House.*

CARNARVON.

BARDSEY ISLAND—*Trinity House.*
ST. TUDWALS—*Trinity House.*

The list of places where no fall of dust was observed is compiled from special inquiries addressed to the authorities whose names are quoted; and in most cases the replies refer to the surrounding neighbourhood as well as to the place named.

I have heard of no case in which the dust was observed to fall dry from the sky. Indeed it would perhaps be correct to speak of the phenomenon as a fall of mud rather than of dust. The rainfall of the period in question, therefore, throws some light on the patchy distribution of the dust. Throughout the whole of the west of England and of Wales there had been no rain for a period ranging from 7 to 12 or more days before the 21st. This dry spell may be taken as having averaged ten days in duration, and at most stations it ceased on the 21st, at a few on the 20th, and at one or two not until the 24th. The following table gives the data on which the rainfall maps for the 21st and 22nd (Figs.

2 and 3) have been constructed. The readings were taken in every case at 9 a.m. on the morning after the date to which they are entered. The order (except that Scilly is included in Cornwall) is that employed in *British Rainfall*.

RAINFALL ON JANUARY 21–23, 1902.

DIVISION V.

County.	Station.	21st. in.	22nd. in.	23rd. in.
Wiltshire	Bishops Cannings	·02	·04	...
,,	Marlborough, Mildenhall	·04	...	...
,,	New Swindon	...	...	·02
Dorset	Portland Bill	...	·01	...
,,	Weymouth	·04	...	·07
,,	Winterbourne Steepleton	·05	...	·15
,,	Blandford, Whatcombe	·03	·04	·23
,,	Shaftesbury	·05	...	·13
Devon	Salcombe	·02	·05	·20
,,	Hove	*	·19	*
,,	Torquay, Cary Green	·02	...	·15
,,	Buckfastleigh	·04	·01	·33
,,	Ashburton, Holne Vicarage	·10	·01	·35
,,	,, Druid House	·04	·01	·24
,,	Tavistock, Whitchurch	·16	·08	·30
,,	Princetown	·34	·10	·40
,,	Polapit Tamar [Launceston]	·04	·02	·18
,,	Sidmouth	·05	·01	·11
,,	Rousdon [Lyme Regis]	·04	...	·13
,,	Exeter	...	·02	·16
,,	Okehampton, Oaklands	·18	·03	·22
,,	Honiton, Combe Raleigh		·08†	·12
,,	Cullompton	·03	·02	·24
,,	Tiverton	·02	·02	·17
,,	Hartland Abbey	...	·08	·17
,,	South Molton, East Street	·09	·03	·15
,,	,, Castle Hill	·05	·02	·10
,,	Barnstaple	·02	·02	·09
,,	Ilfracombe	·04	·02	·26
,,	Lynmouth, Rock House	·01	·01	·18
Cornwall	Tresco Abbey, Scilly	·03	...	·19
,,	St. Mary's, Scilly	...	·01	·01
,,	Penzance	·02	·05	·18
,,	Falmouth Observatory	...	·03	·23
,,	Truro, Killiow	...	·08	·26
,,	Probus, Lamellyn	...	·06	·17
,,	Newquay	·02	·02	·12
,,	Liskeard	·13	·06	·24
,,	Bodmin, Lanhydrock	·10	·05	·19
,,	Bodmin, Fore Street	·10	·02	·19
,,	Launceston, Altarnon	·17	·09	·30
,,	Bude	...	...	...
Somerset	Ilton	·03	...	·10
,,	Wellington	·06	...	·15
,,	North Cadbury	·02	·01	·04
,,	Chewton Priory	*	·02	*
,,	East Harptree Court	·06	·02	·03
,,	Bath	·03	·01	·09
,,	Pawlett	...	...	...

DIVISION VI.

Gloucester	Clifton	·04	·02	...
,,	Lechlade	...	...	...
,,	Cirencester, Further Barton	...	...	·04

* Amount not stated. † Amount for the two days, 21st and 22nd. ... indicates no rain.

DIVISION VI.—*continued.*

County	Station	21st. in.	22nd. in.	23rd. in.
Gloucester	Stroud, Uplield	...	...	·06
"	Fairford, Hatherop	*	...	·02
"	Great Barrington	...	...	·01
"	Gloucester, Llanthony Lock	·01	...	·03
"	Cheltenham	...	...	·01
"	Moreton in the Marsh, Longborough	...	...	...
Hereford	Ross, The Graig	...	...	·04
Worcester	Great Malvern	...	...	·06

DIVISION XI.

Monmouth	Bromley, Wilis Court	·04	·05	·09
"	Cabinet	·03	...	·03
"	Llanfrechfa Grange	...	·01	·12
"	Monmouth	...	...	·07
"	Llanvihangel Court	...	...	...
Glamorgan	Barry Island	*	·03	*
"	Lower Penarth	·02	·05	·03
"	Penarth	·03	·03	·03
"	Cardiff, Ely	·05	·05	·12
"	Llantrisant, Talygarn	·07	·07	·22
"	Neath, Fairy Land	·05	·01	·25
"	Treherbert	·22	·07	·45
Carmarthen	Llanelly	...	...	...
"	Llanelly Reservoir	...	·05	...
"	Carmarthen	·10	...	·31
"	Llandovery	·07	·03	·16
Pembroke	Haverfordwest	·04	...	·34
"	St. Davids	·04	·01	·25
"	Castle Malgwyn	·02	·02	·34
Brecknshire	Brecon, Llandefaelogfach	·03	·03	·06
"	Hay, Gwernyfed Park	...	·03	·10
Cardigan	Aberystwith	·06	·13	·07
"	Aberystwith, Gogerddan	·25	·30	·03

* Amount not stated. ... indicates no rain.

In order to compare the distribution of dust-fall with that of rainfall, it is necessary to endeavour to ascertain the date of the various falls which have been reported, and this involves the weighing of a good deal of uncertain, if not conflicting, evidence. The only date which may possibly refer to a different fall from that which affected most of the stations is January 15, reported at the Smalls Lighthouse off the coast of Pembroke. There is no reason for thinking that this is a mistake in copying the entry from the log, and as one of the two lighthouses near Milford which reports a fall mentions no date, and the other gives January 22, the small Pembroke area may be left out of account, except so far as the date of the 22nd is supported by the neighbouring though isolated areas. At Pencoed a vague newspaper notice refers to the 24th, the exact words of the brief paragraph being: "Heavy showers of rain fell at Pencoed on Friday. On examining the vessels in which it was collected, the rain-water was found to be of a dark drab colour." Here it is not explicitly stated that the discoloured rain-water was not already in the vessels on the previous day, and in any case the observation is not one on which it is necessary to rely.

With these two exceptions, every one of the cases in which a date is mentioned falls between the 21st and 23rd, and there are 39 such

cases with assigned dates amongst the 75 instances of dust being observed. The following analysis of the 39 dates shows that the 22nd was undoubtedly the day when most falls occurred.

Date not quite certain, but between 21st and 23rd	.	.	.	= 3
On 21st, or observed early in morning of 22nd	.	.	.	= 7
On 22nd ,, ,, 23rd	.	.	.	= 24
On 23rd ,, ,, 24th	.	.	.	= 5

The seven cases reported on the 21st include the somewhat doubtful instance at Tresco, that at Great Castle Head in Pembroke (which is

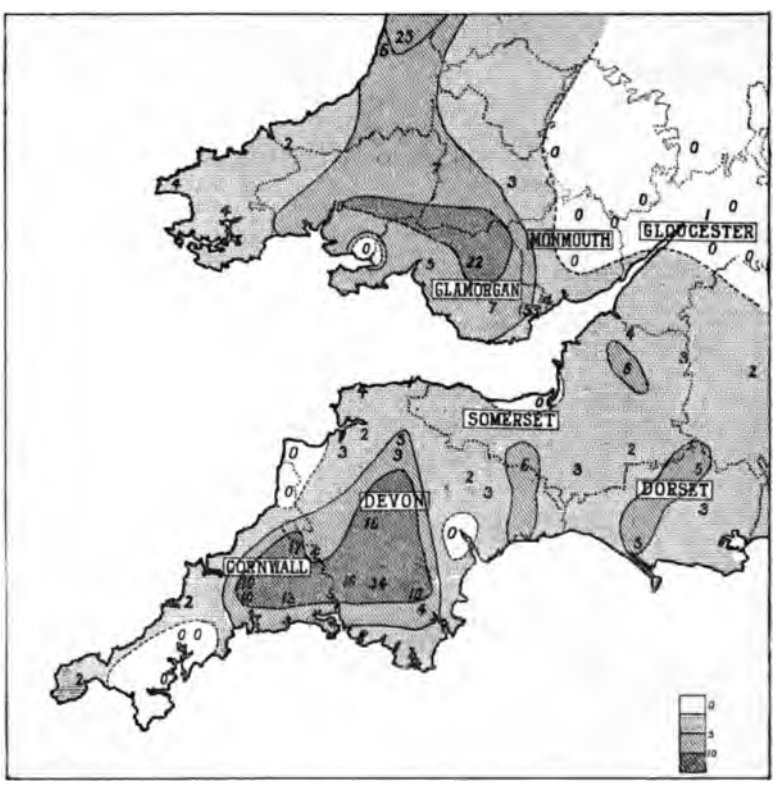


FIG. 2.—Rainfall on January 21, 1902.
(The figures indicate depth of rain in hundredths of an inch.)

assigned to sunrise on the 22nd, and thus falls into the rainfall day of the 21st), Melbury Moor in the small North Devon area, "between the evening of the 21st and the morning of the 22nd," Davidstow in the north of the Cornish area, "at mid-day," and three—Perranporth, Altarnon, and Lewannick, all in Cornwall—for which a fall was also reported on the 22nd. At Perranporth there was apparently no measurable rain on the 21st; but at the North Cornish stations there was a little more than one-tenth of an inch. It seems improbable that so many observers could have mistaken the date, and I am inclined to believe that in the afternoon or evening of January 21 some dust fell with the rain in the

northern part of the Cornish area, and possibly also in the North Devon area.

Looking at the five cases on the 23rd, I think that "a dust-fog" reported at Bere Alston in a newspaper paragraph is too vague to require consideration; and the report from Mill Bay, Plymouth, "between sunset on the 23rd and sunrise on the 24th," is most probably a mistake for the previous day, to which no less than three other stations on Plymouth Sound agree in attributing the dust-fall. To the fall at Perranporth, which is assigned to each of three days, I shall recur later. That at the

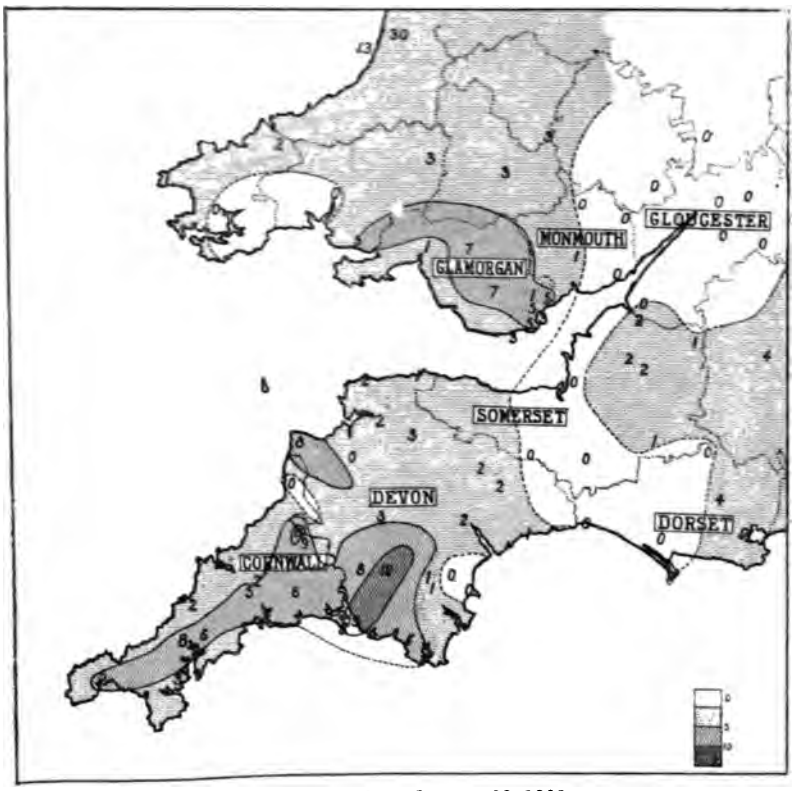


FIG. 3.—Rainfall on January 22, 1902.
(The figures indicate depth of rain in hundredths of an inch.)

West Usk Lighthouse, "between noon and sunset," is possibly correct; while that at East Harptree occurred probably early on the morning of the 23rd, falling within the rainfall day of the 22nd. I am inclined to think that the only dust-falls which can be attributed to the 23rd are some of those in the Somerset area, where, as the observations at Hallatrow and Henbury, and probably also at Failand, show, the fall was general about 7 a.m. on that day. This hour, if it had not been actually recorded, would naturally have been classed as "morning of 23rd" with the rainfall day of the 22nd.

It appears that the great mass of the Cornwall and most of the

South Wales dust-fall areas received their sprinkling on the 22nd; and the Somerset area undoubtedly between 5 p.m. on the 22nd and noon on the 23rd. With the exception of Scorrier, which apparently experienced the fall about noon, and the extreme north of the Cornwall area, which received it the night before, all the other parts were affected during the night of the 22nd-23rd. The south of Cornwall, which was practically rainless on the 21st, had a slight but uniform rainfall (little over ·05 in.) on the 22nd. It will be noticed that the area in Dorset, Eastern Devon, and Somerset, where there was no rain on the 22nd, entirely escaped the dust-fall, and so did the extensive area stretching north through Gloucester, Worcester, and Hereford, in which the drought did not break until the 24th.

It is unfortunate that there are no data available for associating the dust-falls with individual showers; but it seems probable that at any one place the actual fall of muddy rain was of very short duration. If one might venture to picture the condition of things during this period one would imagine a layer of dust-laden air, perhaps very high in the atmosphere, drifting slowly over south-western England and Wales from the 21st to the 23rd, and, when occasional showers fell through it, or perhaps when clouds were condensed on the dust particles as nuclei, producing a muddy rain varying from a few splashes that hardly attracted attention to a quantity sufficient to darken a skylight or paint the suburbs of a coal-shipping port a pleasing pink.

So far the phenomenon has been considered from the point of view of distribution alone; it is now time to consider the nature and origin of the deposit. The best idea of the appearance of the dust will be conveyed in the words of the actual observers, and these—with such slight editorial revision as was necessary in communications not written for publication—are presented in the following extracts. The stations are grouped in counties as in the previous list, following the order familiar to those who consult *British Rainfall*. The authorities cited are those who signed the statement, all the Lighthouse and Light-vessel reports being forwarded by the Trinity House.

Devon.

Plymouth Breakwater Lighthouse.—On the morning of January 23, at sunrise, I noticed a yellow dust on the lantern-gallery, likewise streaks where it had run down over paint-work of pedestal. The weather during the night had been overcast, with occasional showers of drizzle, the wind moderate to light breeze from West to West-north-west, and the deposit on the gallery floor lay from west to north-west. The deposit was very similar to fine brick-dust, dark yellow in colour, and meagre in extent.—W. J. Thomas.

Hospital Ship "Pique," Jenny Clip Bay, Plymouth Sound.—On the morning of January 23 our ship had the appearance of being in a dust-storm. The dust had a reddish colour when it was wet.—C. King.

Thorncot, Hooe, near Plymouth.—On the morning of January 23 the water in the measuring-glass of my rain gauge and that in a barrel fed from the roof of a small greenhouse was much discoloured. I did not observe any of the dust itself, but it must have been very fine, as the water in the barrel did not clear for quite three days. The colour was a warm yellowish grey. I did not detect any red.—John Little.

Lifton.—A relative living at Lifton, near Launceston, wrote to me at the end

of January as follows :—" We had last week a most extraordinary shower of rain, which only lasted a short time. When it was falling it looked like thick soapy water, and next morning over everything in the village, gardens, and fields there was a layer of brown dust."—(Mrs.) MARY HAMMOND.

Parkham, Bideford.—I am informed that several people around this neighbourhood having their linen out overnight had to re-wash it next morning owing to its being saturated with red dust, but of course they do not mention dates.—FRANK HARDING.

Hartland Point Lighthouse.—Very fine dust of a reddish brown colour fell between the night of the 22nd and the morning of the 23rd. Wind South-south-west to South, and weather overcast and misty.—WM. DARLING.

CORNWALL.

Wolf Rock Lighthouse.—I noticed on the morning of January 23 the lantern windows, pedestal, and gallery on the west-south-west side covered as though it had been raining yellow muddy water.—E. K. BALL.

Tresco Abbey, Isles of Scilly.—We had no rain on January 22, but in the ·03 in. which fell on the night of the 21st my gardener, who keeps the register, noticed on the glass spots of muddy rain that had fallen. He did not notice any redness, but one man says there was a little "clay-like red." After a long period of dry weather, especially from the East, so much black sometimes falls from clouds impregnated with smoke that it spoils the blooms of white flowers. On January 22 there were very few white flowers being picked, principally yellow.—T. A. DORRIEN-SMITH.

Seven Stones Light-vessel.—On the morning of January 23 a yellow mud-like appearance was noticed as though everything had been covered with dust, and rain had fallen upon it, all over the ship.—J. GRIFFITHS.

Godrevy Lighthouse.—A dust-like substance fell with the rain about 6 p.m. on January 22, the fall being noticed for about half an hour. It was of a sandy, gritty nature, reddish in colour, and of slight extent.—TRINITY HOUSE.

Scorrier.—On the afternoon of January 22 I noticed that my frame-lights were covered with what I can only describe as resembling splash-marks, such as you see on a hunting man's boots. At first I thought it might be due to gardeners' carelessness, but on going to another walled garden about 200 yards away I found the frame-lights there covered in the same manner, as were also the lights in yet another garden still farther away. Our altitude here is some 400 feet above sea-level, we are situated on the top of a hill, and the two gardens last mentioned are surrounded by high walls and also protected by trees. At the time of the phenomenon the wind was West, with occasional driving misty rain such as is common in Cornwall. The following morning the splashes were still there, and on examining them with a common botanist's lens each was seen to consist of a small particle of gritty substance about the size of a red spider, and sometimes twice that size, surrounded by what looked like very fine sand which had apparently been washed off the gritty particle after it had settled on the glass. The colour of the gritty particle varied from reddish to a dirty yellow as seen through the lens. Where the dust had got into the frames and settled on the leaves of the violets, the tissue of the leaf surrounding the gritty particle presented the appearance of being burnt, thus proving that the dust was injurious.—E. H. WILLIAMS.

St. Austell.—The Mayor of Truro, Mr. John James, in conversation with me mentioned that this dust covered the whole of his China-clay works at Reten about January 22, and his people thought that the stock of clay was ruined, but a shower of rain washed the whole of the dust away, and it did no damage. —JOSEPH TURNER.

St. Austell.—My father has been from home, and still is, but I have got the following information. He does not remember the exact date, but it was a few mornings before the letters on the fall of dust appeared in the papers. The window ledges and small roof on which he saw it faced south. The colour of the dust he described as red, but I think that it would rather be "reddy yellow." My mother also saw it, and she said it appeared "just as though some powder of this colour had been placed in a flour-dredger and scattered over the window ledge and slates." It did not appear to be evenly distributed, but thicker in places, and the slates showing through in others.—J. M. Coon.

Fowey.—On January 23 I found a glass roof at the back of my house covered with a fine dust a shade lighter than snuff. It was thick enough to darken the room considerably. A friend of mine also noticed it on a boat he had tarred the evening before; some of it can yet (February 21) be seen on the tar.—John M. Clemens.

Quethiock.—The washing, which is done here on Wednesday, was put out to dry on January 22, in the afternoon or mid-day, and it was not soiled in the evening; but on Thursday morning, when it was taken in, the maids noticed the mess it was in. They said it looked as if some one had been pouring a brown dirty mixture on the line so that it ran down on the sheets, etc. My gardener said he found the vegetables coated with a sort of brownish powder, like Peruvian guano. This shows that the storm must have been late on the night of the 22nd, or early in the morning of the 23rd. I may add that the rain-water in the tubs outside many of the cottages in the villages and hamlets one to two miles away was of a dirty white colour and unusable.—(Rev.) J. Augustus Wix.

Altarnon.—I am near-sighted, and noticed nothing unusual in the colour of rain measured at 9 a.m. on January 21st, 22nd, or 23rd; but on the 23rd I noticed a yellow deposit on the flat corrugated-iron cover of a soft-water tank. The same day Mr. W. Sleeman (at Five Lanes) showed me the water in his tub, which stood in the open catching rain-water from a roof. He said that finding the water yellow he had emptied it on the 21st, thinking boys had been playing a trick, but found the water caught at the next filling equally yellow, and that the water from the roof was not clean enough for washing for two days or more. Mr. Pearce of this place, seeing the telegraph posts covered with the dust, scratched lines in it with a penknife; these lines still remain yellow, showing that the powder was very adhesive. It is still (February 24) visible on the corrugated-iron cover.—C. U. Tripp.

Somerset.

Chewton Priory.—I regret to say I cannot give you any more information than that contained in my letter to the *Western Daily Press*.[1] I was away from home all day on January 23, and it was not until the 24th that I was aware of the phenomenon; my gardener then called my attention to the stains on paint on the frames. His description was that when he first noticed the dust he thought the chimney of the greenhouse furnace had been on fire, and inquired of the under-gardener if this had been the case; it was only when he found that it had not been so that he thought there was something unusual.—(Earl) Waldegrave.

East Harptree.—A curious layer of reddish-yellow dust fell on the 23rd, covering smooth surfaces such as paint and glass to the depth of about ·01 in. or less. This also happened in other places in the neighbourhood.—W. W. Kettlewell.

Hallatrow.—On Thursday, January 23, I noticed spots like thin mud on the

[1] "Wednesday the 22nd [January] was with us very warm, with wet mist only measuring ·02 in. of rain. Afterwards the glass and woodwork of the greenhouses and frames were covered with a rust-coloured dust, which has left stains on the paint."

glass-houses and pits (glass) in the garden. Laurel leaves, etc., were spotted in a similar way. I believe this muddy shower fell here between 7 and 8 a.m. that day, but it was all over in a very few minutes.—C. A. KEMBLE.

Failand.—My men here noticed on Thursday last, the 23rd inst., that the leaves, glasses of the frames, and iron-work of the gates were smeared with a reddish mud; one hedge in particular they describe as almost covered with the substance; and the pinafores of a cottager's children which were hanging out to dry were so stained with the deposit that they had to be re-washed. When the substance fell no one here knows, nor is it clear whether it fell as dust or mud; from the firm way in which it has attached itself to the iron-work I should think it fell as mud.—Sir EDWARD FRY in *Nature*, February 6.

Flatholme Lighthouse.—On January 22, about 5 p.m., a fall of dust or mud was observed with West-north-west wind. On the lantern glass it looked a dirty white, but when washed off, the water in the bucket had a pink tinge.—TRINITY HOUSE.

English and Welsh Grounds Light-vessel.—On January 22, during the hours from 9.30 p.m. to midnight, with wind from West by South, fog and misty rain, a deposit of brownish dust fell, and when dry was like brown mud.—TRINITY HOUSE.

MONMOUTH.

West Usk Lighthouse.—On January 23, some time between noon and sunset, a fall of dust occurred with South-west wind and overcast, misty weather. The dust was very fine, pinkish in colour, and of amount sufficient to colour the white paint.—TRINITY HOUSE.

Llanfrechfa Grange, Caerleon.—My gardener tells me that on January 22 he believes he noticed on my hothouses and frames a grey dust, and asked the under-gardener if the chimney had been on fire, for the dust was very like soot that had burned nearly white. This had not been the case, and they observed it in such positions as could not have arisen from the soot catching fire in the chimney.—F. J. MITCHELL.

GLAMORGAN.

Barry.—The fall of rain ending 9 a.m. on January 23 was a light one, only ·03 in., the wind very light from the West-north-west. The deposit, like a very fine dust, coated the iron railings and fences with a pale salmon pink colour. I was much struck with some ordinary wire netting which appeared as if it had been painted with a brush. The deposit was particularly noticeable upon Barry Island, although I found it to a lesser extent in Barry itself.—E. W. WAITE.

Merthyr Maur, Bridgend.—In reading the *Morning Post* of Monday I see you ask for information as to "Blood Rain" or dust that was seen in different places on January 22. I remember quite well noticing the spots of dust of a yellowish colour that were on the frames and glass-houses here and remarking it to the men. I thought at first it was because we had been burning rubbish, when I saw it on the frames, but when I looked at the houses it was on them also, so I could not account for it in any way until I saw Monday's paper.—T. THOMAS (gardener to Mr. J. J. D. Nicholl).

PEMBROKE.

Smalls Lighthouse.—During the night of January 15, weather clear and cloudy, wind West-north-west, the weather side of the lantern was covered with a thin coat of reddish-brown gritty dust.—JOHN L. ELLIS.

MERIONETH.

Dolgelly.—About 11 a.m. on January 23, when examining a white marble cross in a churchyard near here, I noticed to my great surprise that it had a

quantity of reddish deposit, like iron rust, especially on the bases of the cross and in the interstices of the carving. I found that it would come off fairly easily on rubbing with a handkerchief. The red deposit was found on several other monuments; it seemed almost like dull powdered red-lead or sheep "raddle." I feared at first that something of this sort had been thrown about, but when I saw how generally it had fallen I concluded that it must have come from the skies. The weather at the time was rather foggy, wet, and mild.—A CORRESPONDENT.

The less complete descriptions sent by other observers contain no points not referred to above. It will be noticed that the colour as a rule was yellowish or brownish, the pink tinge being comparatively seldom noticed.

The actual amount of mud or dust which fell does not appear to have been very great at any point, nor does it seem to have been at all uniform. Possibly the falls were heaviest at Fowey, where the dust darkened a glass roof; in Plymouth Sound, where the hospital ship was plentifully sprinkled; and at Barry, where railings were painted pink. Unfortunately only small quantities were collected at any place, and it has proved most difficult to get specimens. A letter addressed to one gentleman who stated in a local paper that he had a quantity of the dust remains without an answer; the quantities sent by several correspondents who took much trouble in the matter were too minute to enable any satisfactory determination to be made, and we are reduced to two samples of somewhat larger amount—one from South Wales, the other from Cornwall—for material on which to base an opinion as to its nature.

Mr. E. W. Waite, of Barry, sent a sample which he had scraped off a black-varnished railing at Barry Island on the day when his attention was first called to the deposit. It is a light yellowish-pink powder, fine grained and incoherent, and is referred to in the following determination as Sample I.

Rev. J. Augustus Wix, of Quethiock, also kindly sent a specimen obtained from the roof of his greenhouse at Quethiock Vicarage near Liskeard. This was a dark brown earthy-looking powder containing particles which were of quite perceptible size to the naked eye. It is referred to as Sample II.

Sir John Murray, F.R.S., of the *Challenger* Expedition, who has devoted much attention to the analysis of atmospheric dust, and Mr. G. T. Prior, of the Mineralogical Department of the British Museum, were kind enough to send the following reports on Sample I., and Sir John Murray also on Sample II.

SAMPLE I. *Barry Island*—Report by Sir JOHN MURRAY.—The powder is of a light reddish-brown colour, the finer portions being principally made up of minute fragments of minerals, which under the polariscope show brilliant spots of light. The larger and more prominent particles are black and dark brown in colour, probably fragments of the black varnish, and some irregular particles are magnetic, probably particles of iron from the railing. One rounded grain of quartz or felspar, 0·15 mm. in diameter, several grains of felspar (?) about 0·08 mm. in diameter, magnetic metallic cosmic (?) spherules, about 0·015 mm. in diameter, and a few organic fragments (one or two minute diatoms, and probably limbs of small insects) were observed, but otherwise the material is extremely fine grained, principally minute particles of minerals with a mean

diameter of less than 0·02 mm., therefore too small to be specifically determined, mixed with amorphous clayey matter. The whole resembles a clay coloured by the higher oxides of iron.

SAMPLE I.—Report by Mr. GEORGE T. PRIOR.—Although containing some dark organic matter, the powder consists mainly of inorganic particles, viz. minute grains of quartz with flakes of micaceous minerals. The dust appears to be of the same nature as the dust or so-called "blood-rain" which is often carried over from Africa to Europe, even as far north, it is stated, as Hamburg (See Prof. Judd, "Blood Rains," *Nature*, vol. lxiii. (1900-1), p. 514). This dust also, like that described by Prof. Judd, contains remains of diatoms, but in very small amount.

SAMPLE II. *from Quethiock*.—Report by Sir JOHN MURRAY.—The material is grey-brown in colour, incoherent, and contains small rock particles, probably mica-schist, the largest about 2 mm. in length, mixed with fine amorphous matter. A great amount of vegetable matter, fragments of leaves, etc., as well as small insects, legs, and antennæ of insects, were observed. The mineral particles have a mean diameter of 0·25 mm., and consist of quartz, felspar (kaolinised), mica, and magnetite. One or two spherical bodies, about 0·017 mm. in diameter, with a blue-black metallic appearance, were observed; as they were not magnetic, they cannot be regarded as of cosmic origin, and are probably small pellets of slag from a blast-furnace. A minute particle of brassy yellow iron pyrites, very slightly oxidised, was also noticed with many small particles of glass.

For the comparison of the dust from Barry with the undoubted sirocco-borne dust which fell in Sicily last year I am indebted to Mr. Robert Whitaker of Palermo for very kindly forwarding a sample, the colour of which in the mass is a warm pinkish-brown, rather lighter in tint, but otherwise exactly resembling the specimen from Barry. On a small portion of this sample from Sicily Sir John Murray reports as follows:—

The material is very fine grained, incoherent, light in weight, and of a pale brown colour, containing rounded and angular fragments of plagioclastic and orthoclastic (including microcline) felspar, quartz, hornblende, magnetite, and glass, with a mean diameter of 0·07 mm., one angular fragment of glass having a maximum length of 0·16 mm. The finer material consists principally of amorphous clayey matter, with traces of vegetable matter, such as woody fibre and minute portions of leaves; one small diatom was observed. A few extremely minute acicular crystals of what appeared to be apatite were also noticed.

Possibly the material from Sicily may represent the heavier portions of desert sand, etc., taken up and carried by the wind from the Sahara, while the material from Barry Island may represent the lighter portions carried along to a much greater distance.

In the light of these reports I think it is justifiable to look on Sample II. as a collection of local dust with which some of the precipitated dust may have mixed, though in but a small proportion; while Sample I., in default of more explicit information, may be taken as representative of the material of the dust-fall.

Having failed to get more than a strong hint as to the origin of the dust from its microscopical examination, we must look elsewhere for something to lead us further in the direction of certainty. There are practically only three possible origins which require consideration. (1)

Dust due to local winds blowing over dry mud; (2) dust produced by a neighbouring explosion; and (3) dust carried by the wind from a long distance.

Several observers have pointed out that the rain-water collected immediately after a long spell of dry weather very frequently contains quantities of dust; and Mr. Clement Reid, F.R.S., drew attention in *Nature* (March 6, 1902) to the fact that a great expanse of red mud at the mouth of the Red River near St. Ives, when dried, gives off quantities of dust which are carried by even a light wind for several miles, and might thus account for the dust-falls. Against this we have to set the great extent of the phenomenon, ranging over 200 miles from the Wolf Rock Lighthouse to Dolgelly, and over 120 miles from Milford Haven to Castle Cary, and the remarkably uniform descriptions of the dust as observed in all parts of that area. The improbability that local dust could arise simultaneously in so many places, appear so uniform, and attract so much attention, at a time when the wind was light and the weather extremely settled, is so great that the hypothesis may be dropped without apology.

The explosion theory is a little more plausible. A tremendous explosion of dynamite throwing a vast column of débris to a prodigious height in the atmosphere might quite possibly account for all that was seen. And it so happens that an explosion did occur at Nobel's Factory at Perranporth, near Truro, on January 16, about 11.30 a.m., when a small truck laden with gelignite which was being pushed along a tramway exploded and killed three men. Mr. E. Veale, mining engineer, Perranporth, writes:—

> I observed the so-called rain-dust on January 21, again on the 22nd and 23rd. I attribute the above to the explosion of dynamite at Nobel's factory, situated about three-quarters of a mile from my house. For satisfaction I went to the river side a short distance away and there found a similar deposit of dust. The particles of dust which fell at Perranporth would naturally be coarser and heavier than those found in South Wales. I found it to be slightly gritty on rubbing with my finger; on examining with the lens I found quartz and felspar present, ferric oxide would probably form the reddish colour, there were also present particles of metamorphic schist of a micaceous character. The above analysis, I think, would correspond fairly with the strata near the site of the explosion.

For particulars regarding the explosion I applied to the Works Manager, Mr. Joseph Turner, who most courteously supplied the following information:—

> The explosion took place about 1 foot 4 inches above ground-level. A crater was made measuring 20 feet by 15 feet by 3 feet deep, but the earth was not all dislodged. I should say that not a single atom of earth or matter was thrown outside our own property—not by many hundreds of yards. The column of smoke, fumes, and débris did not ascend more than 100 feet high, and from the reports of eye-witnesses the fumes or smoke were all condensed within a quarter of a mile from us in the direction of Truro. This would mean that the wind was North-west at the time. The deposit referred to was perceived on the morning of January 22. I have often noticed such deposits off the coast of Africa whilst at great distances from the land.

Even supposing that *all* the débris, instead of none of it, had entirely disappeared in the air, that would only amount to 900 cubic feet, which, if shattered into the finest dust and scattered so that each particle was well separated from its neighbour, would cover one square mile to a depth of 0·0005 inch (or half the thousandth of an inch), a film which would be practically invisible to the naked eye. Now we have shown that the dust deposit was *visible* over 2000 square miles, so that more than two thousand times the quantity of earth moved but not transported by the Perranporth explosion would be required to be thrown into the air to account for it. The explosion theory accordingly may be laughed out of court.

The theory of distant origin is supported by evidence so strong that I think it must be held to be proved. By an interesting exercise of scientific foresight the Meteorological Office placed upon the *Pilot Chart* for January, published on December 16, a warning that thick dust haze was to be looked for during the month in the Eastern Atlantic, south of the 35th parallel of latitude; and they at once recognised that the phenomena reported from many parts of the coast northward as far as Barry Island were merely an extension of the familiar Atlantic dust haze. This fact was communicated to this Society in a note for the *Quarterly Journal* received early in February.

The facts are that on January 17, in the early morning, the dust-fog unquestionably blown over from the Sahara lay so thick about the Madeira Islands that the mail steamer *Lagos* went ashore on one of the Dezertas and became a total wreck. Other steamers reported a dust-fog at the same time south of latitude 33°. I am not aware that the fog appeared at sea farther north, but on writing to Admiral A. A. de Pina Vidal, the head of the Meteorological Service at Lisbon, for information I received the following interesting communication:—

> It is certain that during the period from January 14 to 22 a reddish-yellow dust fell in nearly all parts of Portugal. The atmospheric phenomena accompanying the fall have been analogous to those experienced in Italy last March, the atmosphere being obscured by a sort of yellowish or greyish fog through which the solar disc could be observed shining feebly.
>
> Professor Achilles Machado, the eminent professor of chemistry at the Polytechnic School in Lisbon, read a paper on this fall of dust at a recent meeting of the Lisbon Academy of Sciences. He had made the qualitative analysis of a specimen of the dust collected on some plants at Grandola, about 50 miles south-east of Lisbon. This dust was of a dark yellow colour, essentially mineral in character, and under the microscope it was seen to be formed of rounded particles and irregular fragments looking like quartz. Qualitative analysis showed that it was composed of silica, alumina, oxide of iron, carbonate of lime, and a small proportion of organic matter.

One further link in the northward progress of the dust is furnished by a note communicated to the Paris Academy of Sciences by M. Sebillant, on February 3. It records the fall of muddy rain about 10 p.m. on January 22, at Périers and Gouville, places about 11 miles apart in the department of La Manche, on the little peninsula of Normandy that runs northward just east of the Channel Islands. The description is exactly like those we have given in detail for England: the water caught in barrels appeared to be soapy, linen spread out to dry was splashed with

reddish stains, and cabbages were powdered yellow. Treating the phenomenon as an isolated one, M. Sebillant sought to explain it by a hypothesis of local origin, into which it is not necessary to enter here.

This area of dust-fall did not seem to extend to the Channel Islands, two observers in Guernsey and one in Jersey assuring me that nothing of the kind was seen there.

The conclusion which seems to be inevitable is that on January 22 the atmosphere over the extreme west of Europe consisted of air which had come from the African deserts, carrying with it a quantity of fine dust which was brought down in perceptible quantities wherever rain happened to fall. The extreme sharpness of the boundary line where the dust-fall was observed seems to indicate a sharply defined dust-cloud in the air. The question whether the identity of desert air may be determined otherwise than by the dust-floats it carries in its current is not without interest, and there is at least some possibility that a more delicate test may be found. In this connection special interest attaches to the following communication from Miss Bertha M. Broadwood, the well-known foundress of the Ockley system of nursing by cottage nurses, which was dated from Capel in Surrey on February 18 :—

> The extract *re* "Blood Rain" in the *Morning Post* of February 17 has interested me particularly, as confirming my conviction that a sirocco had reached this part of the south of England on January 22 and 23 last. It is a wind which is particularly poisonous to me, giving me a feeling of *malaise* and lassitude such as accompanies the fever of malaria, or with me precedes a thunderstorm. I have often experienced it when on the Riviera a South wind blows ; and last year, 1901, on the afternoon of March 12, when a South wind suddenly came on accompanied by a few heavy drops of rain, I remarked that there must be a storm somewhere as I felt so wretched, or that it was the sirocco that had been felt five days previously in Sicily carrying "blood rain." Two days later I saw in the papers that "blood rain" had fallen at Hamburg and also near Great Malvern on March 12. I could not see in the papers any notice of a sirocco on January 22 and 23, and my friends thought me fanciful for saying I was suffering from the effects of one, but your account of it confirms my belief that I was.

The meteorological conditions at the time and for many days before had been typically anticyclonic, with high pressure over the Bay of Biscay and Western Europe, and a gradient north-eastward, leading to Westerly and Southerly winds on the surface. From the 19th to the 23rd the synoptic charts of the *Weekly Weather Report* show that the pressure over the Bay of Biscay, Western France, and Northern Spain remained at or above 30·5 ins., while in the north of Scotland the pressure remained at or near 29·9 ins. (see Figs. 4 to 11, which have been kindly prepared by Commander M. W. C. Hepworth). The winds along the whole coast of Europe north of 40° lat. were South-westerly or Southerly, and south of that parallel (or say south of Lisbon) the wind appears to have been Northerly. It appears not improbable, however, having regard to the Spanish weather-charts of January 20-22, that the anticyclonic system embraced a considerable part of Northern Africa, and that the wind circulating in the direction of clock-hands round the periphery of this high-pressure area blew the desert dust out to sea in the latitude of Madeira, and back to land farther north. However, the data are not precise enough

to justify any definite theorising on the subject. As the wind over Portugal appears from the charts to have been blowing on the whole from the land seaward during the period, it seems more probable that an in draught of dust-laden air in the upper atmosphere was responsible for bringing the dust. But whatever may have been the meteorological

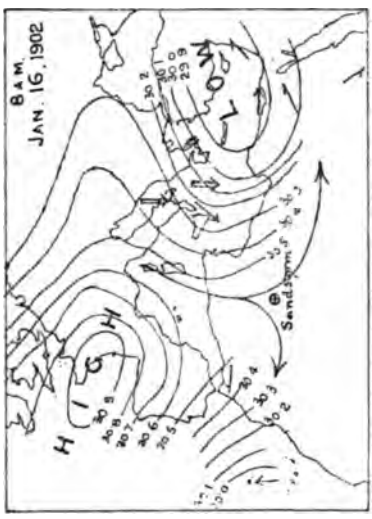


FIG. 5.—Pressure and Winds, January 16.

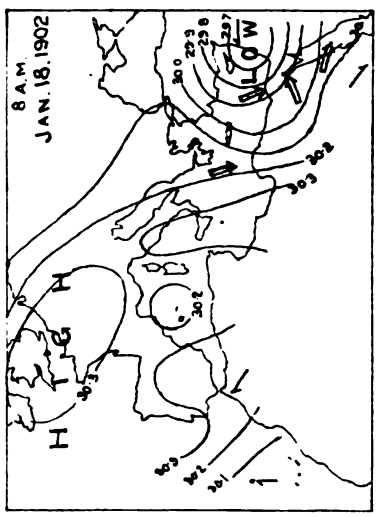


FIG. 7.—Pressure and Winds, January 18.

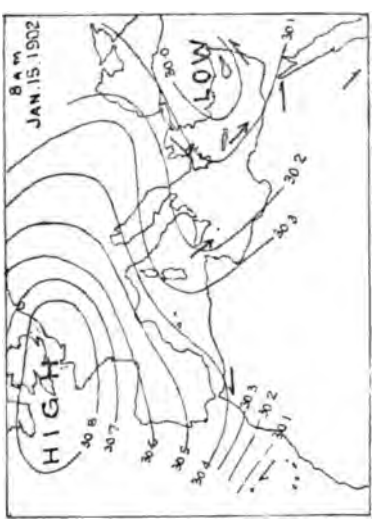


FIG. 4.—Pressure and Winds, January 15.

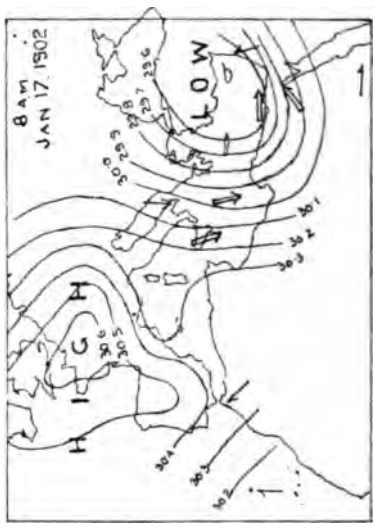


FIG. 6.—Pressure and Winds, January 17.

agency by which the dust-rain of January 22, 1902, reached Northern Europe, it seems perfectly sure that it was not the same as that by which the dust-cloud of March 12, 1901, pursued its roughly parallel course. There is no room in the weather-charts of January 20-23 for a cyclonic centre travelling directly northward across Europe; but we cannot yet tell what the distribution of pressure and wind was in the Atlantic at the time, and whether a centre of low pressure may not have turned the flank

of the anticyclonic area and whisked the dust northward with it. I incline to think that the evidence points to transportation in the upper air, the large amount of dust carried causing a general descent over Portugal through the opposite surface current, and a mere vestige (some 100,000 tons or so) being caught in its fall and carried on to the shores of the

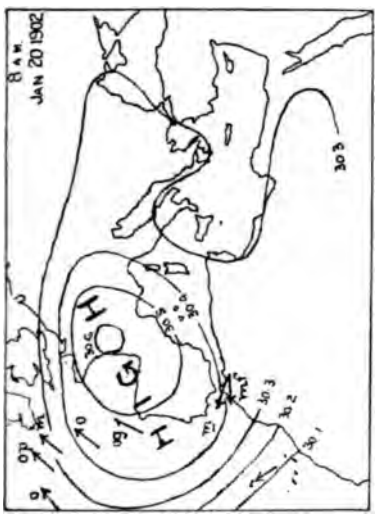


FIG. 9.—Pressure and Winds, January 20.

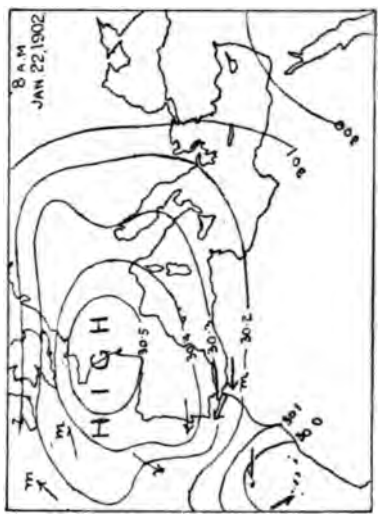


Fig. 11.—Pressure and Winds, January 22.

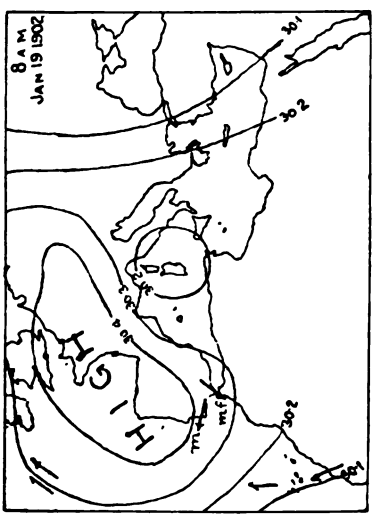


FIG. 8.—Pressure and Winds, January 19.

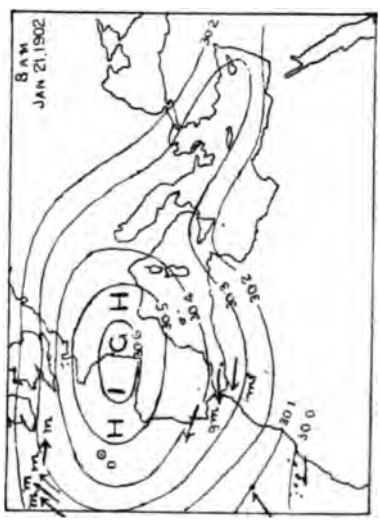


FIG. 10.—Pressure and Winds, January 21.

Channel. The farmers of the west of England have this spring ploughed many tons of the sands of the Sahara into their furrows.

In conclusion, I have a grateful duty to perform in thanking the army of observers whose observations I have set forth for the generous alacrity with which they have co-operated in the work. Most of all, thanks are due to the Elder Brethren of the Trinity House for obtaining and communicating special reports from more than forty lighthouses round the coast of

the area affected. The Meteorological Office, the Royal Meteorological Society, and the observers of the British Rainfall Organization are such old colleagues in meteorological research that their assistance may be almost taken for granted, though it is none the less gratefully appreciated on that account. The courtesy of the distinguished head of the Portuguese Meteorological Service, Admiral de Pina Vidal, cannot be too warmly acknowledged; nor should I less cordially thank Dr. Hellmann, of the Central Meteorological Institute in Berlin, for the advice and assistance he has afforded. It would be almost invidious to refer to the services of any individual observers, but Mr. C. U. Tripp, of Altarnon, threw himself so heartily into the work of collecting information on the spot that an exception must be made in his case. To Mr. J. G. Wood also I owe one excellent description, acknowledged in the list to the observer. To Mr. Waite for having secured an excellent sample of the dust, and to Sir John Murray and Mr. Prior for having examined it, special thanks are due. To all those whose observations are quoted, and to the many other writers of the 337 communications on which this paper is based, I offer equal thanks, including those impersonal members of the Press whose notices of the preliminary summary have very largely aided in making this discussion so complete as it is. Though the matter under research is not of the first scientific importance, and though the result has not conducted us to any brilliant or novel conclusion, I cannot help feeling that this little investigation is of value in demonstrating (though even this is not new) how willing and capable the residents in the country districts of Great Britain are to co-operate in real scientific work when the opportunity is offered.

DISCUSSION.

Mr. W. H. Dines said the Society was much indebted to Dr. Mill for his interesting paper. Meteorologists were also much indebted to dust for the only reliable information they possessed, apart from theory, of the direction of the upper currents, for much had been learnt from the Krakatoa dust. He thought Dr. Mill had established his case that this dust had come from the Sahara, but probably it had never risen to any very great height. These falls of dust also explained the well-known fact that the level of the Sahara was in places considerably below that of the sea, for although these falls were comparatively rare in Europe, vast quantities of the soil in the form of dust were annually deposited on the sea-surface in the neighbourhood of Madeira.

Mr. G. B. Wetherall said that showers of black rain were occasionally experienced round Worcester when the wind was in the North. One instance occurred last week. Presumably the rain fell through the heavy clouds of smoke from the chimneys of the iron factories in the northern part of the county, *i.e.* Dudley and district, bringing with it some of the matter with which they were charged.

Mr. R. Inwards inquired if travellers ever reported where sand of a pinkish tinge could be found. In Africa it was generally yellowish in colour.

Mr. W. B. Tripp remarked that he had heard a great deal about "blood-rain" and similar expressions in connection with these sand-falls in the South of Europe from the Sahara. But he had seen a great deal of yellow sand in South Africa, although he had never seen the Sahara, and he wished to know whether it was known where these red sand deposits existed there. Not having

heard the paper, he did not know whether he was asking for information already given.

Captain D. WILSON-BARKER said that he was struck by the smallness of the amount of inorganic matter in the dust found on analysis. The amount of organic matter, too, rather puzzled him, as it was well known that very little was to be found on the desert; it therefore made it all the more interesting to discover from whence the deposit actually came.

Commander M. W. C. HEPWORTH said he thought it might interest those present to know that a dust storm was reported to have occurred at Ouargla, an oasis 315 miles south by west from Constantine in Algeria on January 16th. This was the only dust storm noted at an Algerian station during the month. Dr. Mill had mentioned that the meteorological conditions at the time of these deposits, and for many days before, being anticyclonic over the Bay of Biscay and over Western Europe, favoured the circulation of wind at first seaward and then northward. Well over the eastern basin of the Mediterranean on January 16th, 17th, and 18th an area of low barometer was situated. Under the influence of this low pressure the wind at Athens was North-west and over Egypt Westerly (North-west to South-west). Presumably the wind was Westerly also over Tripoli and over the Libyan desert. He mentioned this because, on January 17th, the s.s. *Ophir*, proceeding down the Gulf of Suez, encountered a heavy sandstorm, and during the afternoon and night other sandstorms occurred, partially obscuring the land, and at times sand was falling on deck. There were thus two wind systems on these dates over North Africa, the Mediterranean, and South Europe; one carrying dust from Africa towards the Atlantic, and the other carrying dust towards the Gulf of Suez and Red Sea.

It should have been mentioned that during the night of January 17th-18th the *Ophir* was steaming between the Gulf of Suez and The Brothers, islands in the Red Sea. Dust-storms in the north end of the Red Sea are not of frequent occurrence.

Mr. C. HARDING remarked that vessels in the Atlantic often experienced dust-storms, the colour of the deposit generally being of a light pinkish brown. He himself thought it was quite possible that the current could bring in the dust on the western side of the anticyclone. He thought the particles had been carried up to a great height, and afterwards deposited with the rain.

Mr. F. J. BRODIE remarked, in reference to Miss Broadwood's description, that not very much importance could be attached to the lady's feelings with regard to the phenomenon. He thought with Mr. Harding that the dust must have fallen from a great height. After the eruption of Krakatoa no noticeable alteration in the temperature was observed.

Dr. W. P. MAY remarked that dust of the colour described was quite common in Egypt, where there were thousands of sand-storms. The dust deposit there was quite of a mineral nature, and it was often possible after a storm to gather numbers of flowers for some little distance in the desert. Indeed, specimens of flora and fauna were both to be found. He thought one's feelings were at a discount during the occurrence of such a phenomenon as described by Dr. Mill.

Dr. H. R. MILL, in reply, said that black rain was frequently due to the smoke from factory chimneys. Mr. Dorrien-Smith's letter, cited in the paper, showed that such showers even reached the Scilly Isles. Black showers also frequently followed volcanic eruptions. The colour of the deposit from the fall of January over the western side of England was similar to that of the fine residuum of desert sand. The particles were very minute, the heavier portions having been dropped on the way. The Barry Island sample was almost entirely inorganic, but the amount was so small, and the dust was so finely divided, that a

complete analysis was hardly possible. With regard to Commander Hepworth's suggestion, he hardly thought that the low-pressure area on the east of Africa could influence the west coast at the same time. He thought at first, with Mr. Harding, that the dust might have been carried along by the wind circulating round the western side of the anticyclone, but over Portugal the wind was off the land, and the deposit of dust there was very thick. Hence he believed that the dust fell from the upper air over Portugal, and was perhaps caught up and carried on by the surface winds afterwards. He hoped all observers would be on the look-out for dust in the rainfall during the next few weeks, as such deposits, though probably very fine and of small amount, were quite to be expected after the recent eruptions in the West Indies.

Distribution of Fog in Switzerland.—The results of a detailed study of the conditions attaching to the prevalence of fog in Switzerland, somewhat on the lines adopted for Germany by Hugo Meyer and for Great Britain by R. H. Scott, have been put forward by Gottfried Streun in a dissertation for the degree of Doctor in the University of Berne. The author discusses in much detail the distribution of fog in Switzerland, both in time and space, as well as the relations between the general condition of the weather and the occurrence of fog. Some of the broader generalisations only can here be referred to. In the region of valley fog the morning is the time when the phenomenon is most marked, owing to the nightly cooling of the ground and the superincumbent atmosphere; while in the case of mountain fog, the frequency of occurrence is distributed pretty evenly through the day. In the lowlands, again, a clearly marked yearly period is to be traced, while with an increase of altitude this becomes less and less recognisable. The maxima and minima fall at somewhat different times of year in different parts of Switzerland, though at the lower levels the maximum occurs with more or less regularity towards the close of the year (most frequently in November). Already at about 1000 metres the yearly period loses its well-marked character, both valley and mountain fog here occurring side by side. In the higher valleys the maximum occurs in October, and the minimum in winter, while on mountain summits two very slight maxima can be traced in May and October. Dr. Streun gives maps showing the distribution of fog in space, both for the year as a whole and for the winter and summer half-years, as well as a series showing in detail the distribution at short intervals during the autumn of 1897. In the region below 1000 metres, with which alone the maps deal, the greatest frequency of fog occurs in the central lowland, a zone with over fifty days of fog in the year, running along the foot of the first chain of the Jura, with a width of about 15 to 20 miles. On the other hand, fogs are less frequent in the deep Alpine valleys, both in the north and south, which show generally less than twenty days of fog in the year. This is in part due to the influence of the Föhn. Other points touched upon are the average duration of individual periods of fogs at different stations and at different seasons, and the average altitude of the upper limit of fog, with its variations at different hours of the day.—*Geographical Journal*, October 1902.

ENGLISH CLIMATOLOGY, 1891–1900.

By FRANCIS CAMPBELL BAYARD, LL.M., F.R.Met.Soc.

[Read June 18, 1902.]

On June 15, 1892, I read a paper[1] before the Society entitled "English Climatology, 1881-1890," and in it I discussed the climatological observations of *The Meteorological Record* for that period. As a further period of 10 years has now been completed, I have, with the assent of the Council, undertaken to work up the Climatological observations of *The Meteorological*

Map showing the Position of the Stations.

Record for the decade 1891-1900. I propose to deal with these further observations on the same lines as those of the preceding decade, but I hope later on to discuss the observations of all those stations which have continued during the 20 years in a thoroughly exhaustive way.

[1] *Quarterly Journal*, vol. xviii. p. 213.

TABLE I.—Stations and Authorities.

Station.	County.	Height above Sea-level.	Authority.
England, N.E.		Ft.	
Rothbury	Northumberland	400	The late Lord Armstrong, F.R.S., F.R.Met.Soc.
Ushaw	Durham	600	Rev. J. Corbishley, B.A.
Rounton	Yorkshire	249	Sir I. L. Bell, Bart, F.R.S.
Scarborough	Yorkshire	160	W. Robinson.
		160	H. G. Monk, M.D.
		160	H. Littlejohn, F.R.C.S.
		160	E. W. Ellerbeck, F.R.A.S.
		219	
		62	W. W. Larkin.
Driffield	Yorkshire	76	The late J. Lovel, F.R.Met.Soc.; W. E. Lovel.
Lincoln	Lincolnshire	184	C. J. Bromhead, F.R.Met.Soc.
England, E.			
Hillington	Norfolk	89	Rev. H. E. B. Ffolkes, M.A., F.R.Met.Soc.
Lowestoft	Suffolk	84	S. H. Miller, F.R.Met.Soc.; J. E. O'Connor, M.B., F.R.Met.Soc.
Wryde	Cambridge	4	S. Egar, F.R.Met.Soc.
Thurlow	Suffolk	241	A. Boa.
Halstead	Essex	144	E. T. Adams, F.R.Met.Soc.
Chelmsford	Essex	136	J. C. Thresh, D.Sc.
Bennington	Herts	407	Rev. J. D. Parker, LL.D., F.R.Met.Soc.
Midland Co.			
Wakefield	Yorkshire	96	H. Clarke, L.R.C.P., F.R.Met.Soc.; A. Clyde.
Hodsock	Notts	56	H. Mellish, J.P., F.R.Met.Soc.
Buxton	Derby	987	W. H. Beck; F. H. Bowden; F. E. Gunter, M.B.; E. A. Dent, M.B.; H. Harrison; H. L. Apthorp; W. Pilkington.
Belper	Derby	344	J. Hunter, F.R.Met.Soc.
Cheadle	Stafford	646	J. C. Philips, J.P.
Churchstoke	Montgomery	538	P. Wright, F.R.Met.Soc.
Malvern	Worcestershire	520	C. Stephen; S. A. Sturton; F. V. Guy; A. Mander, F.R.Met.Soc.
Burghill	Hereford	275	T. A. Chapman, M.D.; C. S. Morrison, M.B.
Ross	Hereford	213	H. Southall, J.P., F.R.Met.Soc.
Cheltenham	Gloucester	184	The late R. Tyrer, B.A., F.R.Met.Soc.
Ravensthorpe	Northampton	355	G. S. Eunson, F.R.Met.Soc.
Aspley Guise	Bedford	410	E. E. Dymond, F.R.Met.Soc.
Berkhamsted	Herts	400	E. Mawley, F.R.Met.Soc.
England, S.			
Regent's Park	Middlesex	125	W. Sowerby, F.R.Met.Soc.; J. B. Sowerby.
Old Street, E.C.	Middlesex	69	Rev. A. P. Hockin; Rev. J. F. Sugden.

TABLE I.—STATIONS AND AUTHORITIES—*continued.*

STATION.	COUNTY.	Height above Sea-level.	AUTHORITY.
		Ft.	
Norwood . . .	Surrey . .	220	W. Marriott, F.R.Met.Soc.
Addington . .	Surrey . .	472	T. Walker, M.Inst.C.E.
Beddington . .	Surrey . .	120	S. Rostron, J.P., F.R.Met.Soc.
Marlborough . .	Wilts . .	424	C. E. B. Hewitt, B.A. J. A. Ensor. J. Frith. W. Clement Jones, D.Sc. R. S. Cole. President, Natural History Society.
Harestock . . .	Hants . .	300	Lt.-Col. H. S. Knight, F.R.Met.Soc.
Swarraton . . .	Hants . .	310	Rev. W. L. W. Eyre, M.A., F.R.Met.Soc.
Tunbridge Wells .	Kent . .	419	F. G. Smart, M.B., F.R.Met.Soc.
Margate . . .	Kent . .	83	J. Stokes, J.P., F.R.Met.Soc.
Eastbourne . .	Sussex . .	12	Miss W. L. Brodie-Hall, F.R.Met.Soc. Miss L. Hood.
Brighton . . .	Sussex . .	31	A. Newsholme, M.D., F.R.Met.Soc.
Worthing . . .	Sussex . .	33 33 38	W. J. Harris, F.R.C.S., F.R.Met.Soc. G. B. Collet, L.R.C.P., F.R.Met.Soc. C. Kelly, M.D., F.R.Met.Soc.
Portsmouth . .	Hants . .	18	B. H. Mumby, M.D., F.R.Met.Soc. A. M. Fraser, M.D.
Ventnor . . .	Isle of Wight .	80	H. Cleeland. W. R. Watkins. C. Lewis, M.B. Miss M. Gibson.
Weymouth . .	Dorset . .	79	T. B. Groves, F.C.S., F.R.Met.Soc. J. R. Eyles, F.R.Met.Soc. I. J. Brown, F.R.Met.Soc.
ENGLAND, N.W.			
Scaleby . . .	Cumberland .	111	R. A. Allison, J.P., F.R.Met.Soc.
Appleby . . .	Westmorland .	440	C. R. Rivington, J.P., D.L., F.R.Met.Soc.
Seathwaite . .	Cumberland .	422	Mrs. Hughes.
Bolton . . .	Lancashire .	389	W. W. Midgley, F.R.Met.Soc.
Macclesfield . .	Cheshire . .	501	J. Dale. C. Roscoe.
Northwich . .	Cheshire . .	118	J. A. Saner, Assoc.M.Inst.C.E.
Chester . . .	Cheshire . .	63	Rev. J. C. Mitchell, B.D., F.R.A.S.
Blackpool . . .	Lancashire .	62	J. Wolstenholme, Assoc.M.Inst.C.E. A. J. Anderson, M.B.
Llandudno . .	Carnarvon .	88 72	J. Nicol, M.D., J.P., F.R.Met.Soc. W. Little.
ENGLAND, S.W.			
Aberystwith . .	Cardigan . .	59	D. R. Davies, M.B. A. Thomas, M.B.
Gwernyfed Park .	Brecknock .	375	Major T. Wood.
Weston-super-mare .	Somerset . .	22	W. E. Perrett.
Ilfracombe . .	Devon . .	20	M. W. Tattam.
Cullompton . .	Devon . .	202	T. Turner, J.P., F.R.Met.Soc.
Castle Hill . .	Devon . .	363	W. H. Reeve.
Ashburton . .	Devon . .	584	F. Amery, J.P.
Princetown . .	Devon . .	1359	F. W. S. Stone, M.B. J. L. Durbin. E. M. Ellis.
Rousdon . . .	Devon . .	515	The late Sir C. E. Peek, Bart, F.R.Met.Soc.

TABLE I.—Stations and Authorities—*continued.*

Station.	County.	Height above Sea-level.	Authority.
		Ft.	
Sidmouth . . .	Devon . .	148	The late W. T. Radford, M.D., F.R.Met.Soc. Miss Radford.
Torquay . . .	Devon . .	12	A. Chandler. F. March, F.R.Met.Soc.
Newquay . . .	Cornwall . .	100	A. Hardwick, M.D.
Falmouth . . .	Cornwall . .	167	E. Kitto, F.R.Met.Soc.
Ireland.			
Londonderry . .	Londonderry .	67	The late J. Conroy, F.R.Met.Soc.
Ardgillan . . .	Dublin . .	209	Capt. E. R. Taylor, F.R.Met.Soc.
Dublin . . .	Dublin . .	47	Sir J. W. Moore, M.D., F.R.Met.Soc.
Killarney . . .	Kerry . .	86	Ven. Archdeacon Wynne, D.D.
Channel Islands.			
Guernsey . . .	Channel Islands	180	F. E. Carey, M.D., F.R.Met.Soc.

In the year 1891 the Society commenced with 85 stations in the Climatological portion of *The Meteorological Record*, an increase of 7 since December 1890, and the stations at the end of December 1900 numbered 93, an increase of 8 since January 1891. On investigating the records of these stations it was found that there were 69 stations the observations of which were sufficiently complete to justify reduction. This is a net increase of no less than 17 on the previous decade. A list of these stations, with their heights and the names of those responsible for the observations, is contained in Table I., the names of the second order stations being printed in italics; Killarney being considered as a second order station, for it did not become a climatological one till 1897; and Princetown as a climatological station, which it became in 1892. The position of the stations is shown on the map.

Stevenson screens, or modifications thereof, have been used at all stations throughout the decade, except for 1891 and 1892 at Ilfracombe. At Ilfracombe the Stevenson screen has been in use since January 1, 1893, prior to which date was the old screen somewhat like a summer-house. A paper read before the Society on February 21, 1894, gives details of the comparison of the two screens during the year 1893, and shows that the differences do not, even in the case of the minimum thermometer, exceed in any month 1°·4. I have, therefore, accepted the conclusions deduced from that paper, and have considered the temperatures in the two screens to be practically identical.

The rain gauges as a rule are 1 foot above the ground, except for the years 1891 and 1892 at Ilfracombe.

No change in the exposure of the instruments has been made at any of the stations except at Scarborough, Worthing, and Llandudno, the particulars of which are given in Table I. In the excepted stations of Worthing and Llandudno, the distances and difference in elevation being small, the observations have been treated, and may very fairly be

considered, as continuous throughout. The case of Scarborough is, however, different; there the distances and the differences in elevation are rather large, and it may be doubted whether I am correct in treating the observations as continuous, but I have been guided by the opinion of Mr. Marriott, who knows the different positions, and he, though somewhat doubtful, considers that the observations may perhaps be treated as continuous.

The interpolations required have been made by Mr. Marriott. There were 7 stations in which all the observations for a whole year, and not more than two whole years, were missing, but in every case the remaining observations were so good that it was decided to interpolate. The 7 stations in order are: (1) Driffield, the last four months of 1899 and the whole of 1900; (2) Halstead, the whole of 1891 and 1892; (3) Burghill, the whole of 1899 and 1900; (4) Chester, the whole of 1891 and 1892; (5) Torquay, the whole of 1891; (6) Newquay, the whole of 1891 and 1892; and (7) Ardgillan, the whole of 1891.

I propose, as in my former paper, to divide this paper into four main sections, viz. (1) Temperature; (2) Relative Humidity; (3) Amount of Cloud; (4) Rainfall. No correction has been applied for the effect of elevation above mean sea-level. Should, however, any one wish to reduce the temperatures to their equivalent sea-level values, this can be done by applying to the values given in this paper the approximate correction of $+1^{\circ}\cdot0$ for every 270 ft. of elevation above sea-level, the correction found by Dr. Buchan in Bartholomew's *New Physical Atlas* (vol. iii. Meteorology, 1899, p. 6), which is slightly different from the correction mentioned in my former paper of $1^{\circ}\cdot0$ for every 300 ft.

In the Tables the highest and lowest values are printed in thick and italic type.

Temperature.

Before commencing to discuss this portion of my subject, I should like to mention that the decade includes one extremely severe winter, 1894-5, which has already been dealt with by Mr. Marriott and myself (*Quarterly Journal*, vol. xxi. p. 141), and two very warm years, viz. 1893 and 1898, in which the means of the temperatures were as a rule much higher than those of any other year of the same decade. These two facts may tend, perhaps, to modify some of the opinions formerly expressed, but this must perforce be left for another occasion.

On looking through the Table it is evident that Guernsey is the warmest station, if we take the mean temperature alone, $52^{\circ}\cdot4$; but the temperature seems singularly equable, being at 9 a.m. $52^{\circ}\cdot2$, the same as Ventnor, and not so warm as Newquay and Falmouth, which are $52^{\circ}\cdot4$, whilst its minimum temperature is $48^{\circ}\cdot0$, the highest minimum of all the stations, and its maximum $56^{\circ}\cdot8$, in which it is exceeded by no less than 17 stations, and equalled by 3 others. It is evident that the cause of this equability is the sea. The coldest station of all is Buxton, $45^{\circ}\cdot8$, a difference of no less than $6^{\circ}\cdot6$ on the mean temperature of Guernsey, whilst its 9 a.m. temperature is $46^{\circ}\cdot7$, and its minimum $38^{\circ}\cdot3$, a lower temperature than any other station, and its maximum $53^{\circ}\cdot2$, the lowest but three, and the difference between the minimum and maximum is $14^{\circ}\cdot9$, as against $8^{\circ}\cdot8$ for Guernsey. If now we look at

TABLE II.—Mean Temperature at 9 A.M., 1891-1900.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
England, N.E.													
Rothbury	35·1	35·6	38·4	44·4	49·6	56·3	58·5	57·8	53·5	45·3	41·6	37·6	46·1
Ushaw	35·6	36·4	39·6	44·9	49·7	56·5	59·0	58·4	54·8	46·3	42·2	37·9	46·8
Rounton	35·9	36·7	40·1	45·9	50·7	57·2	59·9	59·3	55·3	46·9	42·9	38·2	47·4
Scarborough	37·8	37·9	41·1	46·1	50·2	56·7	60·2	59·9	56·3	48·5	44·7	39·8	48·3
Driffield	35·7	36·5	40·4	47·2	52·1	58·9	61·7	61·1	56·6	47·9	43·2	38·0	48·3
Lincoln	35·4	36·6	40·4	47·1	53·2	59·9	62·6	61·2	56·3	47·0	42·5	38·2	48·4
England, E.													
Hillington	35·6	36·8	40·8	47·6	52·9	59·9	62·6	61·7	57·1	48·5	43·0	38·0	48·7
Lowestoft	37·1	38·4	41·5	47·0	51·6	58·9	62·3	62·5	59·0	50·8	45·5	40·0	49·6
Wryde	35·9	37·9	42·4	49·4	55·1	62·1	65·0	63·9	59·4	49·3	43·2	38·4	50·2
Thurlow	35·2	36·2	40·3	47·2	52·6	59·4	62·3	61·6	57·2	48·4	42·9	38·2	48·5
Halstead	35·8	37·3	41·8	49·1	54·9	61·8	64·5	63·6	59·1	49·7	43·5	38·6	50·0
Chelmsford	36·1	37·3	41·5	48·5	54·3	61·3	64·0	63·3	58·6	49·2	43·4	38·9	49·7
Bennington	35·5	36·8	40·7	47·2	52·5	59·4	62·6	61·6	57·3	48·3	42·9	38·5	48·6
Midland Co.													
Wakefield	37·1	37·4	40·2	46·2	52·0	59·1	61·3	60·4	55·9	47·1	43·8	39·3	48·3
Hodsock	35·8	36·5	41·1	47·3	53·2	59·8	62·4	61·6	57·0	47·3	42·9	38·2	48·6
Buxton	34·9	35·4	39·1	45·3	50·5	57·8	59·0	58·6	55·0	46·3	41·6	36·9	46·7
Belper	36·2	36·2	39·7	45·5	50·8	57·8	60·0	58·8	54·1	46·0	42·4	38·4	47·2
Cheadle	34·9	35·5	38·9	44·9	49·8	56·5	58·4	57·8	54·2	45·7	41·6	37·5	46·3
Churchstoke	36·4	37·2	40·5	46·8	52·2	59·4	61·1	60·3	56·0	47·3	43·2	39·1	48·3
Malvern	37·3	38·6	41·8	47·6	53·3	60·4	62·9	61·5	57·5	48·4	43·8	39·9	49·4
Burghill	36·8	37·5	41·7	48·4	54·3	61·4	63·3	62·1	57·2	47·5	43·3	39·3	49·4
Ross	37·1	37·9	41·8	48·6	54·4	61·3	63·5	62·4	57·5	48·1	43·7	39·9	49·7
Cheltenham	37·3	38·1	41·3	47·9	53·2	60·4	62·5	61·7	56·8	47·9	43·7	40·1	49·2
Ravensthorpe	35·3	35·7	39·4	45·8	51·4	58·7	61·0	60·3	55·5	46·6	42·2	37·9	47·5
Aspley Guise	35·9	37·2	41·3	47·8	53·1	60·2	63·2	62·3	57·6	48·6	43·1	38·9	49·1
Berkhamsted	35·5	36·4	40·2	47·1	52·7	59·5	62·4	61·2	56·9	47·7	42·3	38·1	48·3
England, S.													
Regent's Park	37·8	38·6	41·7	48·5	54·6	61·7	64·7	63·3	58·5	49·5	44·8	40·7	50·4
Old Street, E.C.	39·0	39·8	42·6	48·9	54·6	61·3	64·1	63·2	58·9	50·7	45·9	41·8	50·9
Norwood	37·1	38·2	42·0	48·7	54·6	61·8	64·9	63·7	59·1	49·8	44·4	39·8	50·3
Addington	36·4	37·4	40·3	46·5	52·1	58·9	62·0	61·3	57·1	48·8	43·8	39·5	48·7
Beddington	36·5	37·4	41·3	48·5	54·4	61·5	64·6	63·5	58·3	48·6	43·3	39·0	49·7
Marlborough	36·4	37·2	40·8	48·0	53·1	59·7	62·7	61·8	57·2	47·9	43·0	39·0	48·9
Harestock	36·8	38·0	41·7	49·1	54·2	61·3	63·9	62·9	58·5	49·4	43·8	39·5	49·9
Swarraton	36·5	37·1	40·5	47·6	53·0	59·9	62·3	61·6	57·2	48·3	43·1	39·1	48·9
Tunbridge Wells	36·3	37·4	41·2	48·0	53·4	60·1	63·3	62·5	58·1	49·4	43·8	39·5	49·4
Margate	38·2	39·1	42·4	48·1	53·0	59·5	63·3	63·4	59·7	51·8	46·3	41·5	50·5
Eastbourne	39·8	40·5	43·6	49·9	54·9	60·7	64·2	64·3	60·5	52·3	47·3	43·1	51·8
Brighton	39·4	40·3	43·5	49·7	55·1	61·1	64·0	64·7	61·4	53·0	47·5	42·8	51·9
Worthing	38·5	39·6	42·8	49·3	54·3	60·5	63·6	63·6	60·2	51·7	46·3	41·9	51·0
Portsmouth	38·9	39·8	42·8	49·3	54·6	61·2	64·1	63·6	59·9	51·5	46·3	42·1	51·2
Ventnor	40·4	41·7	44·2	50·0	54·9	60·4	63·8	63·7	61·0	53·4	48·4	44·3	52·2
Weymouth	40·9	41·3	43·4	48·9	53·8	60·1	63·1	62·8	59·8	52·6	48·0	44·8	51·6
England, N.W.													
Scaleby	36·1	36·4	39·8	46·5	52·0	58·9	60·1	59·5	54·9	45·7	42·5	38·6	47·6
Appleby	35·2	35·5	39·0	46·1	51·3	58·7	59·4	58·8	54·2	45·4	42·1	37·3	46·9
Seathwaite	37·3	37·1	39·0	45·9	51·4	58·9	59·3	58·4	53·8	45·6	42·8	40·0	47·5
Bolton	36·8	37·2	39·9	46·0	51·4	58·2	59·6	59·0	55·2	47·0	43·2	39·1	47·7
Macclesfield	35·6	36·1	38·4	45·0	49·8	57·1	58·5	57·9	53·4	45·2	41·9	38·3	46·4
Northwich	37·0	37·7	41·2	48·1	53·8	61·4	62·8	61·8	56·9	47·4	43·4	39·4	49·2
Chester	37·8	39·0	42·6	48·9	54·1	61·4	63·0	62·2	57·7	49·0	44·7	40·6	50·1
Blackpool	38·2	38·6	41·7	47·4	52·7	59·5	61·3	60·8	57·2	49·1	45·0	40·6	49·3
Llandudno	40·8	41·3	43·2	48·1	52·6	59·1	61·0	61·1	58·2	50·9	46·9	43·5	50·6

TABLE II.—Mean Temperature at 9 a.m., 1891-1900—*continued.*

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
England, S.W.													
Aberystwith. .	*41·1*	41·8	43·6	49·1	53·2	59·2	61·1	**61·6**	58·9	52·2	47·9	44·2	51·2
Gwernyfed Park .	*36·6*	37·0	40·1	46·7	52·5	59·5	**61·3**	60·4	55·7	46·8	43·0	39·4	48·3
Weston-super-Mare	*39·5*	39·7	42·5	48·6	53·6	60·5	**63·0**	62·7	58·9	50·6	46·1	42·6	50·7
Ilfracombe . .	*42·8*	43·3	44·8	49·2	52·7	59·3	61·7	**62·2**	60·0	53·4	49·1	45·8	52·0
Cullompton . .	*38·6*	39·6	43·2	49·7	54·9	61·5	**63·8**	62·9	58·7	49·8	44·8	41·6	50·8
Castle Hill . .	*38·0*	38·3	40·9	47·2	51·9	58·7	**60·6**	59·9	55·6	47·5	43·6	41·0	48·6
Ashburton . .	*39·7*	41·1	43·7	49·7	54·3	60·5	**62·7**	62·1	59·2	51·4	46·4	43·1	51·2
Princetown . .	*35·7*	36·7	38·2	44·5	48·4	55·3	**56·6**	56·2	53·7	46·0	42·0	38·9	46·0
Rousdon . .	*38·5*	39·5	41·8	47·4	51·6	57·8	**60·4**	60·2	57·4	49·9	45·5	42·3	49·4
Sidmouth . .	*40·2*	41·3	43·8	49·3	54·0	60·3	**63·1**	62·7	59·5	51·7	46·8	43·8	51·4
Torquay . .	*41·4*	42·6	44·6	49·4	53·2	59·9	**63·3**	63·1	59·9	52·7	47·9	45·0	51·9
Newquay . .	*43·1*	44·0	45·4	49·8	53·3	59·1	61·8	**62·3**	60·0	53·7	49·3	46·8	52·4
Falmouth . .	*42·4*	43·6	45·2	50·3	54·3	60·3	**62·7**	62·5	59·7	53·0	48·6	46·1	52·4
Ireland.													
Londonderry .	*39·1*	40·2	42·0	47·9	54·0	59·7	**60·5**	59·8	54·9	47·2	44·3	41·5	49·3
Ardgillan . .	*39·5*	41·0	42·8	47·8	52·0	57·9	**59·5**	59·3	56·0	48·8	45·3	42·1	49·3
Dublin . .	*40·1*	41·0	42·5	48·2	52·9	59·1	**60·2**	59·7	55·8	48·1	45·5	42·7	49·7
Killarney . .	*41·3*	43·4	45·1	50·4	54·3	59·8	**60·8**	**60·8**	57·7	50·4	46·8	45·2	51·3
Channel Is.													
Guernsey . .	*42·5*	43·1	44·8	49·5	53·3	59·0	62·3	**62·5**	60·3	54·0	49·2	45·7	52·2

the separate months of these two stations, we find in every case at Guernsey the lowest mean is in January and the highest in August, whereas at Buxton the lowest is, except as regards the mean minimum, which is in February, in January, but the highest is in July, a month earlier than at Guernsey. I have dealt thus fully with these two stations as they seem to me to be typical, the one of a marine station and the other of an inland station, and consequently I do not propose to deal with the other stations so minutely. If now we look carefully at the different temperature tables, we shall, I think, find the same feature prominent which Mr. Marriott showed with respect to rainfall (*Quarterly Journal*, vol. xxvi. p. 273), namely, that the temperature as well as the rainfall is higher in the west than in the east. If we take Table V. and compare the first two divisions, namely, England N.E. and E. with England N.W. and S.W., and run our eyes down the annual values in the Table, we cannot but be struck with the great difference, which is from 1°·0 to 1°·5 in favour of the western side. This difference also seems to run through the individual months. Where, however, the dividing line between West and East is I do not at present know, but I shall hope to go more closely into the subject next session, when I come to deal with the values of the 20 years 1881-1900.

I will now deal with the temperature tables more in detail. If we compare the yearly values in Table II. with those in Table V., we shall find that out of the 69 stations the 9 a.m. value is higher than the mean value in every case except 16, the greatest excess being at Wryde, 1°·7. In the 16 excepted cases, five, namely, Rothbury, Malvern, Ross, Addington, and Castle Hill, have their 9 a.m. and mean values alike, whilst the remaining eleven, namely, Lincoln, Bennington, Cheadle,

TABLE III.—Mean Minimum Temperature, 1891-1900.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
England, N.E.													
Rothbury	**30·4**	30·6	32·2	36·0	39·6	46·2	*49·5*	*49·5*	45·7	39·1	36·9	32·6	39·0
Ushaw	**31·3**	31·4	33·2	36·8	40·5	47·4	50·4	*50·7*	46·7	40·5	37·7	33·5	40·0
Rounton	**30·9**	31·3	32·5	36·0	39·6	46·8	49·8	*49·9*	45·9	39·4	37·5	33·1	39·4
Scarborough	**33·5**	33·6	35·1	38·9	42·4	49·3	52·3	*52·6*	48·9	42·4	39·8	35·4	42·0
Driffield	**30·9**	31·5	32·9	36·5	40·6	47·3	*49·8*	*49·8*	46·2	40·1	37·8	33·0	39·7
Lincoln	**31·6**	32·6	34·6	38·5	42·7	49·8	52·5	*52·6*	48·6	41·6	38·4	34·1	41·5
England, E.													
Hillington	**31·0**	31·8	33·4	37·4	42·1	48·9	*51·7*	51·5	47·3	41·3	37·9	33·6	40·7
Lowestoft	**32·9**	33·5	35·0	39·3	43·6	50·0	53·7	*53·8*	50·4	44·2	40·6	35·6	42·7
Wryde	**30·1**	30·6	32·4	35·9	41·0	47·9	50·9	*51·1*	46·5	40·0	36·4	32·1	39·6
Thurlow	**30·4**	31·2	33·0	36·7	41·7	48·1	*51·3*	51·2	47·3	41·2	37·3	33·2	40·2
Halstead	**31·1**	31·7	33·7	37·3	42·2	49·0	*51·9*	51·8	47·6	41·4	37·6	33·7	40·8
Chelmsford	**31·1**	31·6	33·3	37·2	41·8	48·3	*51·8*	51·5	47·6	41·2	37·5	33·5	40·5
Bennington	**31·8**	32·5	33·9	38·0	42·2	49·0	*52·2*	*52·2*	48·6	41·8	38·0	34·3	41·2
Midland Co.													
Wakefield	**32·3**	32·8	34·1	37·4	41·9	48·8	*51·5*	51·4	47·3	40·4	38·4	34·3	40·9
Hodsock	31·3	**31·2**	33·4	36·6	41·1	48·0	*51·0*	50·9	46·7	40·0	37·6	33·4	40·1
Buxton	29·7	**29·5**	31·0	34·9	38·9	46·0	*49·4*	49·3	44·8	38·2	36·1	31·9	38·3
Belper	32·0	**31·8**	33·9	37·9	42·5	49·3	*52·1*	51·9	47·5	40·8	37·9	33·8	41·0
Cheadle	**31·6**	32·2	33·6	37·9	41·9	48·7	*51·4*	51·3	47·5	40·9	37·9	33·7	40·7
Churchstoke	**31·7**	**31·7**	32·7	36·9	40·5	47·3	50·1	*50·2*	46·0	39·9	37·4	34·1	39·9
Malvern	**33·6**	34·1	35·7	40·3	44·1	51·1	*53·7*	53·5	50·2	43·0	39·7	35·9	42·9
Burghill	32·5	**32·4**	34·2	38·8	43·0	49·1	*51·9*	51·7	47·3	40·9	38·2	34·4	41·2
Ross	**32·8**	33·1	34·4	39·1	43·3	49·9	*52·8*	52·5	48·0	41·3	38·8	35·2	41·8
Cheltenham	**32·3**	32·9	33·5	38·0	42·1	49·1	*52·1*	51·6	46·8	40·9	38·1	35·0	41·0
Ravensthorpe	**30·7**	31·2	33·1	37·2	42·0	48·4	*51·3*	51·1	47·0	40·8	37·4	33·1	40·3
Aspley Guise	**31·4**	31·8	33·5	37·3	41·8	48·7	51·6	*51·8*	47·7	41·3	37·5	33·7	40·7
Berkhamsted	**31·8**	32·2	33·6	37·3	42·0	48·6	*51·7*	51·6	47·5	41·0	37·7	34·2	40·8
England, S.													
Regent's Park	**33·8**	34·4	35·9	40·6	45·1	51·7	*54·9*	54·7	50·4	43·9	40·3	36·1	43·5
Old Street, E.C.	**35·3**	36·0	37·6	42·2	46·7	53·7	*57·1*	56·7	52·8	46·0	42·1	38·1	45·4
Norwood	**33·0**	33·5	34·9	39·0	43·4	50·1	*53·4*	52·9	49·1	42·6	39·3	35·2	42·2
Addington	**32·2**	33·0	34·7	38·9	43·1	50·0	*53·3*	*53·3*	49·4	43·2	39·5	35·2	42·2
Beddington	**31·6**	32·3	33·9	37·7	42·6	49·5	*52·9*	52·5	47·9	41·6	37·7	33·6	41·2
Marlborough	**31·0**	31·7	32·6	36·7	40·3	46·6	*49·7*	49·4	44·8	39·4	36·9	33·1	39·4
Harestock	**32·2**	32·5	33·7	37·9	42·3	49·0	*52·3*	51·9	47·9	41·4	38·2	34·6	41·2
Swarraton	**32·0**	32·2	33·4	37·5	41·6	48·2	*51·7*	*51·7*	47·2	41·1	37·8	34·1	40·7
Tunbridge Wells	**32·1**	32·8	34·6	38·8	43·0	49·5	*52·6*	52·5	48·7	42·4	38·9	34·6	41·7
Margate	**34·0**	34·8	36·6	40·7	45·3	51·6	55·4	*55·8*	52·5	46·0	41·6	36·5	44·2
Eastbourne	**35·9**	36·2	37·6	41·9	46·2	52·4	55·7	*56·2*	52·1	46·3	42·7	38·8	45·2
Brighton	**35·6**	36·1	37·4	42·2	46·3	52·6	56·1	*56·5*	52·8	46·6	42·8	38·3	45·3
Worthing	**34·3**	34·9	36·2	40·9	44·9	51·3	54·9	*55·3*	51·4	45·3	41·4	37·0	44·0
Portsmouth	**35·0**	35·6	36·7	41·3	45·7	52·3	55·6	*56·0*	51·9	45·7	41·6	37·9	44·6
Ventnor	**37·0**	37·7	38·6	42·8	46·5	53·0	56·3	*57·1*	54·3	48·5	44·4	40·6	46·4
Weymouth	**36·6**	37·1	38·0	42·5	46·4	52·6	55·7	*56·3*	53·6	47·5	43·4	40·1	45·8
England, N.W.													
Scaleby	31·7	**31·5**	33·4	37·5	41·2	47·9	*50·9*	50·7	46·7	39·6	37·8	33·7	40·2
Appleby	**30·0**	30·2	32·1	35·9	39·8	46·6	*49·6*	49·3	45·0	38·3	36·4	32·2	38·8
Seathwaite	33·1	**32·6**	34·1	39·0	42·6	49·5	*51·8*	*51·8*	47·8	40·9	38·5	35·4	41·4
Bolton	**33·1**	33·4	34·9	39·0	43·1	49·7	*52·2*	*52·2*	48·5	41·9	39·4	35·1	41·9
Macclesfield	**31·8**	32·6	33·8	38·4	42·1	49·3	51·9	*52·1*	47·7	40·9	38·1	34·2	41·1
Northwich	**32·1**	32·5	33·9	38·0	42·5	49·3	*52·2*	52·1	47·9	40·9	38·2	34·4	41·2
Chester	**33·3**	33·9	35·5	39·4	43·5	50·3	53·1	*53·2*	49·1	42·1	39·5	35·7	42·4
Blackpool	33·7	**33·6**	35·2	39·6	43·5	50·6	53·5	*53·7*	50·1	42·6	39·8	35·8	42·6
Llandudno	**36·8**	37·0	38·0	41·9	45·5	51·9	54·6	*55·2*	52·1	45·7	42·4	39·2	45·0

TABLE III.—MEAN MINIMUM TEMPERATURE, 1891-1900—*continued.*

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, S.W.	°	°	°	°	°	°	°	°	°	°	°	°	°
Aberystwith .	36·9	37·4	37·9	42·3	45·9	52·4	55·4	*55·9*	52·9	46·2	43·3	40·1	45·6
Gwernyfed Park .	31·0	31·0	32·6	37·1	40·4	46·3	49·5	*49·7*	45·0	39·1	37·0	33·3	39·3
Weston-super-Mare	35·7	35·9	37·4	42·3	46·5	53·1	*56·4*	56·2	52·6	45·7	41·8	38·3	45·2
Ilfracombe . .	39·5	39·4	40·4	44·4	48·0	54·1	57·0	*57·8*	54·8	49·1	45·4	42·4	47·7
Cullompton . .	33·5	34·0	34·9	39·5	43·4	49·4	*52·2*	52·0	47·7	41·6	38·7	36·0	41·9
Castle Hill . .	32·8	33·4	34·1	38·4	42·6	48·3	*51·2*	51·1	47·2	41·0	38·1	35·6	41·2
Ashburton . .	35·9	36·8	37·7	42·2	45·6	51·7	54·5	*54·7*	51·6	45·6	42·0	39·0	44·8
Princetown . .	31·9	32·7	33·6	38·4	41·4	47·9	50·5	*51·0*	48·0	41·7	38·1	35·1	40·9
Rousdon . .	35·0	35·5	36·5	40·7	44·2	50·6	53·3	*53·8*	50·7	44·6	41·1	38·0	43·7
Sidmouth . .	35·6	36·3	37·1	41·4	44·9	51·0	53·8	*54·2*	51·1	45·2	41·7	38·7	44·3
Torquay . .	37·2	38·1	38·5	43·0	46·8	52·8	55·6	*55·7*	52·4	46·7	43·3	40·3	45·9
Newquay . .	39·1	39·6	40·1	44·2	47·2	53·0	56·2	*56·5*	53·7	48·0	44·5	42·6	47·1
Falmouth . .	38·5	39·5	39·4	43·7	46·6	52·6	55·4	*55·6*	53·1	47·4	44·2	42·1	46·5
IRELAND.													
Londonderry .	34·8	35·4	36·4	40·1	43·9	49·9	51·9	*52·1*	48·3	41·7	39·5	36·5	42·5
Ardgillan . .	35·1	35·6	35·9	40·1	43·4	49·5	51·8	*52·0*	48·3	42·4	40·1	37·0	42·6
Dublin . .	36·7	37·4	38·0	42·4	45·6	52·2	*54·3*	54·2	50·3	43·5	41·5	38·8	44·6
Killarney . .	35·3	36·9	37·2	41·1	43·5	49·7	52·6	*52·9*	49·0	42·1	39·3	39·2	43·2
CHANNEL ISLANDS.													
Guernsey . .	39·9	40·1	40·8	44·6	47·9	53·4	56·7	*57·6*	55·7	50·3	46·3	42·8	48·0

Berkhamsted, Ravensthorpe, Old Street, Macclesfield, Weston-super-Mare, Princetown, Dublin, and Guernsey, have their mean higher than their 9 a.m. mean, the greatest excess being at Macclesfield, 1°·3. It is difficult to account for these anomalous readings, but possibly the situation of the stations may have something to do with it.

In *January*, Buxton has the lowest mean temperature, 34°·7, and then come three stations situate a long distance apart, namely, Appleby with 35°·5, Thurlow with 35°·6, and Ravensthorpe with 35°·7. The other stations under 40°·0 are distributed all over the country, and it by no means necessarily follows that the coldest are in the North. The stations over 40°·0 will illustrate this proposition well. They are 14 in number, and arranged in order of temperature are as follows: Weston-super-Mare 40°·1, Sidmouth 40°·3, Ashburton 40°·6, Weymouth 40°·7, Llandudno 40°·8, Ventnor and Aberystwith 40°·9, Dublin 41°·2, Killarney 41°·3, Torquay 41°·7, Falmouth 42°·6, Ilfracombe and Newquay 42°·8, and Guernsey 42°·9.

In *April* we have a somewhat different state of things. Buxton again has the lowest mean temperature, 43°·7, but it is closely followed by Rothbury 43°·8, Ushaw 44°·2, Rounton and Princetown 44°·3, Appleby 44°·7, and Driffield 44°·8. The other stations under 48°·0 are again well distributed. The stations of 48°·0 and upwards are 20 in number, and when arranged in order of temperature are: Norwood 48°·0, Eastbourne and Sidmouth 48°·1, Regent's Park and Cullompton 48°·3, Ross 48°·4, Portsmouth, Weymouth, and Killarney 48°·5, Dublin 48°·6, Brighton and Newquay 48°·7, Ventnor, Weston-super-Mare, and Torquay 48°·9, Falmouth 49°·0, Ilfracombe 49°·1, Ashburton 49°·3, Guernsey 49°·6, and Old Street 49°·7.

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]													
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE IV.—MEAN MAXIMUM TEMPERATURE, 1891–1900—*Continued.*

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, S.W.													
Aberystwith .	44·9	46·3	47·7	53·6	57·8	63·6	65·0	**65·5**	62·7	55·9	51·6	48·2	55·2
Gwernyfed Park .	42·4	45·0	48·9	55·6	60·9	67·9	**69·3**	68·6	64·5	54·6	49·4	45·3	56·0
Weston-super-Mare	44·5	46·3	49·4	55·6	60·2	67·0	**68·7**	68·6	65·3	56·9	51·4	47·6	56·8
Ilfracombe . .	46·2	47·0	48·6	53·8	57·6	64·1	65·8	**66·1**	63·6	56·8	52·6	49·4	56·0
Cullompton . .	44·6	47·0	50·5	57·3	61·9	68·9	**70·6**	69·7	66·4	57·0	51·2	47·7	57·7
Castle Hill . .	43·8	45·8	48·6	54·9	59·4	66·6	**68·3**	67·8	64·3	55·5	50·6	47·0	56·1
Ashburton . .	45·3	47·4	50·6	56·4	60·8	67·0	**69·3**	68·6	65·6	57·5	52·0	48·3	57·4
Princetown . .	40·3	41·9	43·5	50·4	54·7	61·5	**62·6**	62·1	58·9	50·8	46·6	43·6	51·4
Rousdon . .	42·9	44·6	47·4	52·7	57·4	63·2	**65·5**	65·3	62·5	55·3	50·1	46·8	54·5
Sidmouth . .	45·0	46·8	49·2	54·8	59·3	65·5	**68·1**	67·7	64·7	56·9	52·1	48·7	56·6
Torquay . .	46·2	47·9	49·6	54·9	59·5	65·5	**68·3**	67·7	64·7	57·3	52·5	49·3	57·0
Newquay . .	46·5	47·6	48·9	53·2	57·1	62·8	65·3	**65·6**	63·4	56·6	52·6	50·2	55·8
Falmouth . .	46·6	48·0	49·7	54·4	58·8	64·9	**67·3**	67·0	64·0	57·2	52·8	50·1	56·7
IRELAND.													
Londonderry .	43·9	46·3	49·1	55·5	60·3	**67·0**	66·5	66·3	62·9	53·8	49·3	45·9	55·6
Ardgillan . .	43·9	45·8	48·0	52·6	56·8	63·0	**64·5**	64·1	61·2	53·7	49·7	46·4	54·1
Dublin . .	45·6	47·3	49·7	54·8	59·4	65·8	**66·9**	66·3	62·6	54·6	51·1	48·1	56·0
Killarney . .	47·2	48·9	50·8	55·9	59·9	65·5	**65·9**	65·7	63·3	55·9	52·0	50·2	56·8
CHANNEL ISLANDS.													
Guernsey . .	45·9	47·0	49·6	54·5	59·0	64·7	67·8	**67·9**	65·7	57·7	52·6	49·0	56·8

In *July* the range of temperature is very similar, but we have a somewhat different arrangement of stations. Princetown is now the lowest with 56°·5, then Rothbury with 57°·3, and then Buxton with 57°·9. The stations under 62°·0 are again well distributed. Those stations with a mean temperature of 62°·0 and above are 14 in number, and arranged in order are: Weymouth 62°·0, Chelmsford and Eastbourne 62°·1, Weston-super-Mare and Guernsey 62°·2, Ross, Margate, and Ventnor 62°·5, Beddington, Brighton, and Portsmouth 62°·8, Norwood 63°·1, Regent's Park 63°·7, and Old Street 64°·5.

In *October* we have again a somewhat similar range of temperature, but on a descending scale. The lowest is Buxton with 45°·3, then Appleby with 45°·6, and Rothbury with 45°·9. The highest means, 52°·0 and over, are eight in number, and arranged in order are: Torquay 52°·0, Newquay and Falmouth 52°·3, Brighton and Weymouth 52°·4, Ilfracombe 53°·0, Ventnor 53°·2, and Guernsey 54°·1.

In Table III., the mean minimum temperature, we have a somewhat similar order, though, of course, the temperatures are lower, and the distribution slightly different. In *January*, Buxton is the lowest, with 29°·7; then come in order: Appleby 30°·0, Wryde 30°·1, Rothbury and Thurlow 30°·4, Ravensthorpe 30°·7, and Rounton and Driffield 30°·9. The stations, to the number of twenty, 35°·0 and upwards, are as follows, in order of temperature: Portsmouth and Rousdon 35°·0, Ardgillan 35°·1, Old Street and Killarney 35°·3, Brighton and Sidmouth 35°·6, Weston-super-Mare 35°·7, Eastbourne and Ashburton 35°·9, Weymouth 36°·6, Dublin 36°·7, Llandudno 36°·8, Aberystwith 36°·9, Ventnor 37°·0, Torquay 37°·2, Falmouth 38°·5, Newquay 39°·1, Ilfracombe 39°·5, and Guernsey 39°·9.

TABLE V.—MEAN TEMPERATURE, 1891–1900.

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.	Year.
ENGLAND, N.E.													
Rothbury	35·9	37·0	39·4	43·8	47·8	54·7	**57·3**	57·1	53·4	45·9	42·3	38·0	46·1
Ushaw	35·9	37·0	39·7	44·2	48·3	55·2	**58·0**	57·8	53·8	46·3	42·5	38·3	46·4
Rounton	36·1	37·3	39·9	44·3	48·1	55·6	**58·3**	57·9	53·9	46·3	42·9	38·4	46·6
Scarborough	37·8	38·6	41·1	45·1	48·7	56·0	59·1	**59·2**	55·7	48·0	44·7	40·0	47·8
Driffield	36·1	37·4	40·2	44·8	49·3	56·1	**58·8**	58·6	54·6	47·2	43·2	38·2	47·0
Lincoln	36·3	38·2	41·7	47·0	51·6	58·9	**61·4**	60·9	56·6	48·1	43·4	38·8	48·6
ENGLAND, E.													
Hillington	36·2	38·1	41·4	46·3	51·0	58·4	**61·2**	60·7	56·5	48·7	43·5	38·9	48·4
Lowestoft	37·5	38·7	41·0	45·4	49·7	56·5	60·4	**60·6**	57·4	50·1	45·5	40·4	48·6
Wryde	36·0	38·0	41·5	46·6	51·4	58·9	**61·8**	61·3	56·9	48·2	42·9	38·3	48·5
Thurlow	35·6	37·4	40·5	45·8	50·6	57·7	**60·4**	60·0	55·9	48·1	43·1	38·5	47·8
Halstead	36·4	38·3	41·6	47·1	52·2	59·2	**61·8**	61·3	57·0	48·9	43·7	39·2	48·9
Chelmsford	36·5	38·2	41·3	46·9	52·0	59·1	**62·1**	61·3	56·9	48·7	43·6	39·3	48·9
Bennington	36·4	38·3	41·4	47·0	51·3	58·6	**61·7**	61·0	57·1	48·7	43·3	39·4	48·7
MIDLAND CO.													
Wakefield	37·5	38·5	41·1	45·9	50·5	57·8	**60·0**	59·5	55·3	47·3	43·9	39·6	48·1
Hodsock	36·9	38·2	41·7	46·4	50·9	58·0	**60·6**	60·2	55·8	47·8	43·7	39·0	48·3
Buxton	34·7	35·9	38·4	43·7	48·2	55·5	**57·9**	57·5	53·2	45·3	41·4	37·4	45·8
Belper	36·5	37·6	40·8	46·1	50·5	57·8	**60·0**	59·4	55·0	47·0	42·9	38·6	47·7
Cheadle	36·0	37·6	40·4	45·5	49·9	56·8	**58·9**	58·5	54·6	46·8	42·7	38·4	47·2
Churchstoke	36·8	38·1	40·6	45·9	50·0	57·2	**59·2**	58·8	54·8	46·9	43·1	39·4	47·6
Malvern	37·7	39·3	42·1	47·8	52·3	59·6	**61·9**	61·1	57·3	48·8	44·1	40·3	49·4
Burghill	37·6	39·1	42·0	47·9	52·5	59·4	**61·5**	60·9	56·4	48·0	43·9	39·8	49·1
Ross	37·9	39·6	42·4	48·4	53·2	60·2	**62·5**	61·5	57·1	48·5	44·4	40·4	49·7
Cheltenham	37·5	39·1	41·6	47·2	51·9	59·2	**61·8**	60·8	56·1	48·1	44·1	40·4	49·0
Ravensthorpe	35·7	37·3	40·6	45·9	50·6	58·0	**60·4**	59·9	55·6	47·5	42·7	38·4	47·7
Aspley Guise	36·2	38·0	41·2	46·7	51·2	58·4	**61·4**	60·8	56·5	48·1	43·1	38·9	48·4
Berkhamsted	36·7	38·5	41·5	46·9	51·7	58·6	**61·6**	61·0	56·9	48·5	43·6	39·5	48·8
ENGLAND, S.													
Regent's Park	38·0	39·4	42·4	48·3	53·6	60·6	**63·7**	62·7	58·3	49·9	44·9	40·7	50·2
Old Street, E.C.	39·4	40·8	43·6	49·7	54·5	61·6	**64·5**	63·7	59·6	51·2	46·4	42·2	51·4
Norwood	37·7	39·5	42·4	48·0	52·9	59·9	**63·1**	62·1	58·0	49·5	44·8	40·5	49·9
Addington	36·6	38·5	41·0	46·7	51·4	58·4	**61·5**	60·9	57·0	48·9	44·2	39·7	48·7
Beddington	37·0	38·8	41·9	47·4	52·6	59·6	**62·8**	62·0	57·4	48·9	43·9	39·4	49·3
Marlborough	36·7	38·3	40·6	46·3	50·6	57·3	**60·0**	59·2	54·9	47·4	43·1	39·1	47·8
Harestock	37·3	39·1	41·9	47·4	52·0	59·0	**61·8**	61·1	57·1	48·9	44·1	40·1	49·2
Swarraton	37·0	38·6	41·2	46·9	51·3	58·0	**60·9**	60·4	56·2	48·4	43·7	39·6	48·5
Tunbridge Wells	36·8	38·9	41·6	47·1	52·0	58·8	**61·7**	61·0	57·3	49·2	44·2	39·8	49·0
Margate	38·3	39·8	42·3	47·1	51·8	58·6	62·5	**62·6**	59·0	51·4	46·2	41·4	50·1
Eastbourne	39·5	40·7	42·8	48·1	53·2	59·3	62·1	**62·4**	58·7	51·7	46·8	43·0	50·7
Brighton	39·7	40·8	43·1	48·7	53·5	59·7	62·8	**63·1**	59·7	52·4	47·3	42·9	51·2
Worthing	38·8	40·1	42·2	47·9	52·7	58·7	61·6	**61·9**	58·5	51·4	46·4	41·9	50·2
Portsmouth	39·5	40·8	43·1	48·5	53·4	59·9	**62·8**	**62·8**	59·1	51·5	46·6	42·7	50·9
Ventnor	40·9	42·1	43·9	48·9	53·4	59·2	62·5	**62·7**	60·0	53·2	48·4	44·4	51·6
Weymouth	40·7	41·5	43·2	48·5	52·9	59·1	62·0	**62·2**	59·2	52·4	47·7	44·3	51·1
ENGLAND, N.W.													
Scaleby	36·9	37·9	40·5	46·0	50·3	57·3	**59·0**	58·8	54·4	46·9	43·2	39·1	47·5
Appleby	35·5	36·7	39·4	44·7	49·2	56·2	**58·0**	57·3	53·1	45·6	42·1	37·7	46·3
Seathwaite	37·4	37·8	40·0	45·9	50·6	57·6	**58·7**	58·0	54·2	46·8	43·1	39·8	47·5
Bolton	37·4	38·4	40·8	46·0	50·5	57·5	**59·1**	58·7	55·0	47·6	43·8	39·6	47·9
Macclesfield	36·4	38·1	40·5	46·0	50·2	57·7	**59·5**	59·3	55·0	47·1	43·0	39·0	47·7
Northwich	37·8	39·2	41·9	47·1	52·0	59·1	**61·3**	60·7	56·4	48·4	44·1	40·3	49·0
Chester	38·4	40·0	42·5	47·8	52·3	59·5	**61·4**	61·0	57·0	49·0	44·9	41·2	49·6
Blackpool	38·3	39·0	41·2	46·6	51·2	58·1	**60·1**	60·0	56·4	48·9	44·8	40·8	48·8
Llandudno	40·8	41·6	43·1	47·7	51·6	58·1	60·5	**60·7**	57·5	50·5	46·8	43·5	50·2

TABLE V.—MEAN TEMPERATURE, 1891-1900—*Continued.*

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, S.W.													
Aberystwith. .	*40·9*	41·9	42·8	47·9	51·9	58·0	60·2	**60·7**	57·8	51·1	47·4	44·1	50·4
Gwernyfed Park .	*36·7*	38·0	40·7	46·4	50·7	57·1	**59·4**	59·1	54·8	46·8	43·2	39·3	47·7
Weston-super-Mare	*40·1*	41·1	43·4	48·9	53·4	60·1	62·2	**62·4**	59·0	51·3	46·6	43·0	51·0
Ilfracombe . .	*42·8*	43·2	44·5	49·1	52·8	59·1	61·4	**61·9**	59·3	53·0	48·9	45·9	51·8
Cullompton . .	*39·0*	40·5	42·7	48·3	52·7	59·1	**61·4**	60·9	57·0	49·3	45·0	41·9	49·8
Castle Hill . .	*38·4*	39·6	41·3	46·7	50·9	57·5	**59·7**	59·5	55·7	48·2	44·4	41·3	48·6
Ashburton . .	*40·6*	42·2	44·1	49·3	53·2	59·4	**61·9**	61·6	58·6	51·5	47·0	43·7	51·1
Princetown . .	*36·2*	37·3	38·6	44·3	48·1	54·7	**56·5**	**56·5**	53·5	46·2	42·4	39·3	46·1
Rousdon . .	*38·9*	40·1	41·9	46·7	50·8	56·9	**59·5**	**59·5**	56·7	49·9	45·6	42·4	49·1
Sidmouth . .	*40·3*	41·6	43·1	48·1	52·1	58·2	**61·0**	**61·0**	57·9	51·0	46·9	43·7	50·4
Torquay . .	*41·7*	43·0	44·1	48·9	53·1	59·3	**61·9**	61·7	58·6	52·0	47·9	44·7	51·4
Newquay . .	*42·8*	43·6	44·5	48·7	52·1	57·9	60·8	**61·0**	58·6	52·3	48·6	46·4	51·4
Falmouth . .	*42·6*	43·7	44·6	49·0	52·7	58·7	**61·4**	61·3	58·5	52·3	48·5	46·1	51·6
IRELAND.													
Londonderry .	*39·3*	40·9	42·7	47·8	52·1	58·5	**59·2**	**59·2**	55·6	47·8	44·3	41·3	49·1
Ardgillan . .	*39·5*	40·7	42·0	46·4	50·1	56·2	**58·1**	**58·1**	54·7	48·1	44·9	41·7	48·4
Dublin . .	*41·2*	42·3	43·9	48·6	52·5	59·0	**60·6**	60·2	56·4	49·1	46·3	43·4	50·3
Killarney . .	*41·3*	42·9	44·0	48·5	51·8	57·5	**59·3**	**59·3**	56·1	49·0	45·7	44·6	50·0
CHANNEL ISLANDS.													
Guernsey . .	*42·9*	43·6	45·1	49·6	53·5	59·1	62·2	**62·7**	60·6	54·1	49·5	45·9	52·4

In *April* we have a somewhat similar range. Buxton is the lowest with 34°·9, then come Wryde and Appleby with 35°·9, and Rothbury with 36°·0. The stations with the highest mean minimum of 42°·0 and upwards number thirteen, and in order of temperature are: Old Street, Brighton, and Ashburton 42°·2, Aberystwith and Weston-super-Mare 42°·3, Dublin 42°·4, Weymouth 42°·5, Ventnor 42°·8, Torquay 43°·0, Falmouth 43°·7, Newquay 44°·2, Ilfracombe 44°·4, and Guernsey 44°·6.

In *July* we have seven stations below 50°·0, and they stand in the following order: Buxton 49°·4, Rothbury and Gwernyfed Park 49°·5, Scaleby 49°·6, Marlborough 49°·7, and Rounton and Driffield 49°·8. The stations with the highest temperatures, 55°·0 and upwards, are fourteen in number, and stand in the following order: Margate, Aberystwith, and Falmouth 55°·4, Portsmouth and Torquay 55°·6, Eastbourne and Weymouth 55°·7, Brighton 56°·1, Newquay 56°·2, Ventnor 56°·3, Weston-super-Mare 56°·4, Guernsey 56°·7, Ilfracombe 57°·0, and Old Street 57°·1.

In *October* the stations with the lowest temperatures are: Buxton 38°·2, Appleby 38°·3, Rothbury and Gwernyfed Park 39°·1, Rounton and Marlborough 39°·4, Scaleby 39°·6, and Churchstoke 39°·9. Those with the highest temperatures, 47°·0 and upwards, are six in number, and are in order: Falmouth 47°·4, Weymouth 47°·5, Newquay 48°·0. Ventnor 48°·5, Ilfracombe 49°·1, and Guernsey 50°·3.

With respect to the mean maximum temperature (Table IV.) we have in *January* some very curious anomalies. Buxton, as might be expected, is the lowest, with 39°·7, and the other stations in order up to 41°·0 are: Cheadle and Princetown 40°·3, Ushaw 40°·5, Thurlow and Ravensthorpe 40°·7, Appleby 40°·8, Lincoln, Belper, and Macclesfield 40°·9, and

TABLE VI.—MEAN RELATIVE HUMIDITY AT 9 A.M. 1891-1900

STATION.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, N.E.	%	%	%	%	%	%	%	%	%	%	%	%	%
Rothbury	91	88	84	78	73	76	77	79	82	87	90	89	83
Ushaw	89	87	82	77	74	75	74	79	79	84	88	89	81
Rounton	89	86	84	79	78	77	76	79	82	87	90	88	83
Scarborough	90	89	85	82	81	81	79	81	82	86	90	91	85
Driffield	90	88	83	77	73	74	73	77	81	85	90	90	82
Lincoln	90	87	82	75	70	71	71	75	80	87	91	89	81
ENGLAND, E.													
Hillington	91	89	84	77	77	75	74	78	81	90	92	91	83
Lowestoft	90	88	83	79	78	76	74	76	79	84	88	89	82
Wryde	92	89	84	76	76	76	73	77	78	88	92	92	83
Thurlow	93	90	85	77	75	75	74	77	80	87	91	93	83
Halstead	92	87	81	74	72	72	70	75	78	87	91	91	81
Chelmsford	92	89	83	76	71	74	73	74	79	88	91	92	82
Bennington	91	88	82	75	72	71	69	74	78	87	91	90	81
MIDLAND CO.													
Wakefield	88	87	85	77	75	74	75	77	80	85	88	87	82
Hodsock	89	89	81	75	70	73	71	75	79	87	91	90	81
Buxton	91	87	85	77	75	74	76	78	80	85	89	90	82
Belper	88	86	84	78	75	75	76	81	84	89	90	88	83
Cheadle	91	89	86	80	76	79	80	82	84	89	93	92	85
Churchstoke	89	87	83	79	73	74	73	77	81	86	89	88	82
Malvern	88	86	80	75	71	71	71	76	79	86	89	89	80
Burghill	91	89	83	76	71	70	70	75	80	88	90	90	81
Ross	89	88	79	75	70	71	71	75	80	88	89	88	80
Cheltenham	91	88	84	78	74	75	75	78	83	88	90	88	83
Ravensthorpe	...	...	...	...	...	...	...	...	...	...	...	...	...
Aspley Guise	92	88	83	76	73	74	70	74	81	88	93	92	82
Berkhamsted	93	89	83	75	71	72	70	75	80	88	95	91	82
ENGLAND, S.													
Regent's Park	87	85	80	75	69	69	68	74	78	84	88	87	79
Old Street, E.C.	87	83	79	74	68	70	69	74	76	83	87	86	78
Norwood	90	85	80	73	69	68	67	71	76	84	89	89	78
Addington	90	86	82	75	70	72	70	75	79	85	89	89	80
Beddington	91	87	81	75	69	70	68	73	79	88	91	90	80
Marlborough	93	89	87	79	74	75	75	77	83	88	93	92	84
Harestock	92	88	83	75	70	70	70	74	80	86	92	93	81
Swarraton	91	89	85	75	71	73	74	77	83	90	92	92	83
Tunbridge Wells	91	88	81	73	70	71	71	74	80	86	90	91	81
Margate	91	88	83	79	76	76	74	75	78	83	88	89	82
Eastbourne	88	86	82	76	74	76	75	77	78	82	86	87	81
Brighton	89	87	81	76	73	76	74	74	75	81	86	87	80
Worthing	89	87	82	76	73	75	74	76	77	83	87	89	81
Portsmouth	91	88	83	78	73	72	73	75	78	83	89	90	81
Ventnor	88	86	81	77	74	77	75	77	76	81	84	86	80
Weymouth	88	86	81	80	74	77	76	78	79	82	84	86	81
ENGLAND, N.W.													
Scaleby	91	90	88	81	77	78	81	82	85	90	91	91	85
Appleby	91	87	83	77	75	74	76	79	84	87	90	91	83
Scathwaite	85	83	84	78	73	75	77	79	81	83	84	85	81
Bolton	90	87	83	75	70	72	75	78	81	85	88	90	81
Macclesfield	89	88	86	80	76	78	79	83	86	88	90	90	84
Northwich	91	89	85	79	75	73	73	76	81	88	91	91	83
Chester	89	88	83	77	73	74	73	77	81	86	87	88	81
Blackpool	89	88	83	78	73	75	75	79	81	84	87	90	82
Llandudno	83	82	78	76	72	75	75	76	77	79	82	81	78

TABLE VI.—MEAN RELATIVE HUMIDITY AT 9 A.M. 1891-1901—*Continued.*

STATION.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, S.W.	%	%	%	%	%	%	%	%	%	%	%	%	%
Aberystwith .	*85*	82	80	76	**73**	78	79	78	80	79	82	84	80
Gwernyfed Park .	*90*	88	84	79	**74**	75	76	77	82	88	89	89	83
Weston-super-Mare	*91*	89	85	82	80	81	**79**	81	83	88	89	90	85
Ilfracombe . .	*87*	85	84	84	**81**	83	84	82	83	84	85	*87*	84
Cullompton . .	86	85	78	74	**69**	70	71	75	79	85	87	*88*	79
Castle Hill . .	*89*	88	85	80	**76**	77	80	82	85	88	*89*	*89*	84
Ashburton . .	*90*	86	81	77	**73**	75	75	78	81	86	89	*90*	82
Princetown . .	93	91	87	**82**	**82**	83	86	87	86	92	95	*96*	88
Rousdon . .	*92*	89	84	81	**78**	81	8	84	84	88	91	90	85
Sidmouth . .	*89*	86	8	78	**74**	78	75	77	80	83	88	87	81
Torquay . .	*87*	85	79	75	**73**	**73**	74	76	79	82	86	86	80
Newquay . .	87	85	84	83	**81**	**81**	**81**	82	**81**	83	86	*88*	84
Falmouth . .	*88*	85	82	77	**73**	76	77	78	80	84	86	87	81
IRELAND.													
Londonderry .	88	88	83	79	**74**	76	78	81	85	87	88	*89*	83
Ardgillan . .	*89*	86	82	80	**77**	78	79	81	82	85	87	88	83
Dublin . .	*86*	85	81	77	**74**	75	77	80	83	*86*	*86*	*86*	81
Killarney . .	*90*	87	82	80	**76**	78	82	83	83	87	87	88	84
CHANNEL ISLANDS													
Guernsey . .	*89*	87	88	87	86	86	86	86	**84**	86	*89*	*89*	87

Bennington, Aspley Guise, and Addington 41°·0. The stations with the highest temperatures, 44°·0 and upwards, number fifteen, and are in order: Weston-super-Mare and Cullompton 44°·5, Weymouth 44°·6, Ventnor and Llandudno 44°·7, Aberystwith 44°·9, Sidmouth 45°·0, Ashburton 45°·3, Dublin 45°·6, Guernsey 45°·9, Ilfracombe and Torquay 46°·2, Newquay 46°·5, Falmouth 46°·6, and Killarney 47°·2.

In *April* we have again some very curious anomalies, and the lowest temperatures, that is, below 53°·0, number ten, and are in order: Princetown 50·4, Scarborough 51°·2, Lowestoft 51°·5, Rothbury and Ushaw 51°·6, Buxton 52°·5, Ardgillan 52°·6, and Rounton, Seathwaite, and Rousdon 52°·7. The highest temperatures, 56°·0 and above, number nineteen, and are in order: Aspley Guise, Regent's Park, Swarraton, and Chester 56°·1, Hodsock 56°·2, Northwich 56°·3, Ashburton 56°·4, Cheltenham and Berkhamsted 56°·5, Chelmsford 56°·6, Burghill 56°·9, Halstead, Norwood, and Harestock 57°·0, Old Street 57°·1, Beddington 57°·2, Cullompton 57°·3, Wryde 57°·4, and Ross 57°·6.

In *July* we have ten places with a mean maximum temperature under 66°·0, and they are in order: Princetown 62°·6, Ardgillan 64°·5, Aberystwith 65°·0, Rothbury and Newquay 65°·3, Seathwaite and Rousdon 65°·5, Ushaw 65°·6, Ilfracombe 65°·8, and Killarney 65°·9. The highest temperatures, 70°·0 and above, occur at twenty-four stations, and are in order: Malvern and Portsmouth 70°·0, Swarraton 70°·1, Hodsock 70°·2, Marlborough 70°·3, Lincoln and Northwich 70°·4, Collumpton 70°·6, Hillington and Tunbridge Wells 70°·7, Bennington and Aspley Guise 71°·1, Burghill 71°·2, Cheltenham and Harestock 71°·3, Berkhamsted 71°·6, Halstead and Old Street 71°·8, Ross 72°·1, Regent's Park 72°·3, Chelmsford 72°·5, Wryde and Norwood 72°·6, and Beddington 72·7.

In *October* there are six places with a mean maximum temperature under 53°·0, and they are in order: Princetown 50°·8, Ushaw 52°·3, Buxton 52°·5, Seathwaite 52°·6, Rothbury 52°·7, and Cheadle 52°·8. There are eleven stations with 57°·0 and above, and, as will be seen from the list, they are situate mostly in the south, and they are in order as follows: Cullompton 57°·0, Eastbourne and Falmouth 57°·2, Worthing, Weymouth, and Torquay 57°·3, Portsmouth and Ashburton 57°·5, Ventnor and Guernsey 57°·7, and Brighton 58°·1.

Relative Humidity.

This division of our subject is very curious, and at present I can give no reason for the anomalies. I ask myself in vain for a reason why in the annual columns of Table VI. Llandudno should have the same relative humidity as Old Street and Norwood, viz. 78; and why Cullompton and Regent's Park should each be 79; and why Malvern, Ross, Addington, and Beddington (inland stations) should have the same value, 80, as the sea-coast stations of Brighton, Ventnor, Aberystwith, and Torquay; and why the high-level station of Buxton should be 82 and Princetown 88.

If now we turn to the several months we shall find many anomalies. In *January* the stations with 87 and below number nine, and are in order: Llandudno 83, Seathwaite and Aberystwith 85, Dublin 86, and Regent's Park, Old Street, Ilfracombe, Torquay, and Newquay 87. The stations with a relative humidity over 91 are 8 in number, and are divided into three groups. In England E. we have the four stations Wryde, Halstead, and Chelmsford 92, and Thurlow 93; in the Midland Counties we have Aspley Guise 92 and Berkhamsted 93; and in England S. there are Harestock 92 and Marlborough 93.

In *April* the relative humidity is much lower than in January; in fact, the only station with a comparatively high one is Guernsey. The stations with 75 and less are eighteen in number, and are: Norwood and Tunbridge Wells 73, Halstead, Old Street, E.C., and Cullompton 74, Lincoln, Bennington, Hodsock, Malvern, Ross, Berkhamsted, Regent's Park, Addington, Beddington, Harestock, Swarraton, Bolton, and Torquay 75. The stations with a relative humidity of 80 and above are fourteen in number, and are: Cheadle, Weymouth, Macclesfield, Castle Hill, Ardgillan, and Killarney 80, Scaleby and Rousdon 81, Scarborough, Weston-super-Mare, and Princetown 82, Newquay 83, Ilfracombe 84, and Guernsey 87.

In *July* the relative humidity is lower than in April, partly no doubt owing to the rise in temperature. There are eleven stations with a relative humidity of 70 and below, and they are: Norwood 67, Regent's Park and Beddington 68, Bennington and Old Street, E.C., 69, Halstead, Burghill, Aspley Guise, Berkhamsted, Addington, and Harestock 70. The stations with a relative humidity of 80 and above are nine in number, and are: Cheadle and Castle Hill 80, Scaleby, Rousdon, and Newquay 81, Killarney 82, Ilfracombe 84, and Princetown and Guernsey 86.

In *October* the relative humidity is very much higher, and it is very singular that both the stations with the smallest amount should be in North Wales. The stations with a relative humidity of 83 and below number fourteen, and are: Llandudno and Aberystwith 79, Brighton and Ventnor 81, Eastbourne, Weymouth, and Torquay 82, and Old

Street, E.C., Margate, Worthing, Portsmouth, Seathwaite, Sidmouth, and Newquay 83. The stations with the highest relative humidity of 89 and above number six, and are: Belper and Cheadle 89, Hillington, Swarraton, and Scaleby 90, and Princetown 92.

Amount of Cloud.

This branch of our subject also presents several anomalies. In the yearly column of Table VII. we have Belper in the Midland Counties with the smallest amount, 5·3, and Brighton in England S. with 5·7, whilst in distinct contrast with these two stations we have Seathwaite and Killarney with 7·2, Appleby 7·3, Churchstoke and Bolton 7·5, Old Street, E.C., 7·7, Londonderry 7·8, and Wakefield and Ravensthorpe 7·9.

If we now turn to the monthly columns of Table VII. we have in *January* nineteen stations with an amount of cloud below 7·0, and they are in order: Belper and Llandudno 6·2, Dublin 6·5, Brighton, Ventnor, and Weymouth 6·6, Scarborough, Ross, and Torquay 6·7, Ushaw, Portsmouth, Ashburton, and Rousdon 6·8, and Rothbury, Driffield, Lincoln, Blackpool, Newquay, and Falmouth 6·9. And we have ten very cloudy stations with a mean of 8·0 and above; they are in order: Wakefield, Berkhamsted, and Swarraton 8·0, Chelmsford, Marlborough, Bolton, and Londonderry 8·1, Beddington 8·2, and Ravensthorpe and Old Street, E.C., 9·0.

In *April* the stations as a rule are less cloudy, but we have some curious anomalies. There are fifteen stations with an amount of cloud 5·9 and less, and they are in order: Belper 5·0, Llandudno 5·2, Ventnor 5·4, Brighton and Torquay 5·5, Portsmouth and Weymouth 5·6, Cullompton 5·7, Ross and Aberystwith 5·8, and Driffield, Blackpool, Gwernyfed Park, Ashburton, and Guernsey 5·9. There are ten stations which may be considered as cloudy, that is, with an amount of cloud 7·0 and upwards, and they are in order: Bennington, Addington, Beddington, and Killarney 7·0, Rounton and Churchstoke 7·1, Londonderry 7·4; Old Street, E.C., 7·5, Ravensthorpe 7·6, and Wakefield 8·2.

In *July* there is somewhat less cloud than in April, but not so much less as one might expect. There are fourteen stations with an amount of cloud under 6·0, and they are in order: Belper 4·3, Brighton 5·1, Portsmouth, Ventnor, and Torquay 5·4, Blackpool and Guernsey 5·5, Llandudno and Ashburton 5·7, Gwernyfed Park 5·8, and Thurlow, Eastbourne, Worthing, and Weymouth 5·9. The most cloudy places, 7·0 and above, are eighteen in number, and are in order: Bennington, Aberystwith, and Dublin 7·0, Rounton, Scaleby, Bolton, and Castle Hill 7·1, Cheadle and Old Street, E.C., 7·2, Ravensthorpe, Seathwaite, and Macclesfield 7·3, Appleby 7·4, Wakefield 7·6, Churchstoke and Ardgillan 7·7, Killarney 7·8, and Londonderry 8·3.

In *October* we have an amount of cloud rather similar to that in the month of April, with no very violent contrasts, but yet presenting curious anomalies. There are seven stations only with an amount of cloud of 6·0 and less, and they are: Belper 5·5, Brighton, Portsmouth, and Dublin 5·7, Driffield 5·8, Ventnor 5·9, and Llandudno 6·0. There are sixteen stations which we may consider as cloudy ones with an amount of cloud of 7·0 and upwards, and they are: Hillington,

TABLE VII.—Mean Amount of Cloud (0–10) at 9 A.M.—1891–1900.

Station.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
England, N.E.													
Rothbury	6·9	6·7	*6·0*	6·4	6·5	6·4	6·7	6·7	6·1	6·6	7·5	6·4	6·6
Ushaw	6·8	6·5	*6·0*	6·8	6·7	6·7	6·7	6·8	6·2	6·4	7·3	6·4	6·6
Rounton	7·3	7·0	6·8	7·1	7·0	7·1	7·1	7·2	*6·5*	6·8	7·5	7·1	7·0
Scarborough	6·7	6·5	6·1	6·1	6·1	6·1	6·2	6·5	*5·9*	6·3	7·3	6·8	6·4
Driffield	6·9	6·4	5·9	5·9	6·2	6·2	6·3	6·4	*5·8*	*5·8*	7·3	6·8	6·3
Lincoln	6·9	6·5	6·1	6·3	6·1	6·3	6·1	6·1	*5·5*	6·3	7·3	6·8	6·4
England, E.													
Hillington	7·7	7·0	6·7	6·8	6·6	6·8	6·8	6·2	*5·8*	7·0	7·9	7·4	6·9
Lowestoft	7·4	7·0	6·5	6·7	6·6	6·7	6·5	6·3	*5·7*	6·5	7·4	7·0	6·7
Wryde	7·0	6·6	6·6	6·5	6·6	6·6	6·6	6·6	*6·0*	6·8	7·3	6·6	6·7
Thurlow	7·8	6·8	6·1	6·2	6·3	6·1	5·9	6·2	*5·8*	6·8	7·4	7·2	6·6
Halstead	7·8	7·3	6·7	6·7	6·5	6·5	6·4	6·4	*6·0*	6·6	7·7	7·5	6·8
Chelmsford	8·1	7·5	6·7	6·6	6·6	6·6	6·4	6·4	*6·1*	6·8	8·0	7·9	7·0
Bennington	7·8	7·5	7·0	7·0	6·9	7·2	7·0	*6·4*	6·5	7·0	8·0	7·4	7·1
Midland Co.													
Wakefield	8·0	7·9	7·9	8·2	*7·6*	7·7	*7·6*	7·8	7·6	*7·6*	8·2	8·1	7·9
Hodsock	7·2	6·8	6·6	6·9	6·5	7·2	6·9	7·0	*6·4*	6·6	7·6	7·1	6·9
Buxton	7·9	7·5	6·8	6·9	*6·4*	6·6	6·9	7·1	6·7	6·8	7·9	7·7	7·1
Belper	6·2	5·8	5·1	5·0	4·4	4·6	*4·3*	4·7	4·9	5·5	7·1	6·5	5·3
Cheadle	7·6	7·0	6·8	6·6	*6·5*	6·8	7·2	7·5	6·7	6·8	7·8	7·5	7·1
Churchstoke	7·8	7·5	7·1	7·1	*7·0*	7·1	7·7	7·6	7·4	7·6	8·5	7·8	7·5
Malvern	7·1	6·7	*5·9*	6·3	6·1	6·3	6·5	6·6	6·0	6·4	7·2	7·0	6·5
Burghill	7·1	7·0	*5·9*	6·5	6·0	6·2	6·7	6·7	6·3	6·7	7·4	7·0	6·6
Ross	6·7	6·3	*5·5*	5·8	5·7	5·7	6·1	6·2	5·9	6·4	6·9	6·7	6·2
Cheltenham	7·4	6·9	6·6	6·5	*6·1*	6·3	6·7	6·9	6·6	6·7	7·1	7·0	6·7
Ravensthorpe	9·0	8·4	7·8	7·6	7·4	7·4	*7·3*	*7·3*	*7·3*	8·1	8·9	8·7	7·9
Aspley Guise	7·5	6·9	6·5	6·7	6·4	6·9	6·9	6·7	*6·1*	6·7	7·7	6·9	6·8
Berkhamsted	8·0	7·6	6·6	6·7	*6·4*	6·7	6·7	6·6	6·5	6·8	8·2	7·5	7·0
England, S.													
Regent's Park	...	...	...	...	...	...	...	...	...	...	...	...	...
Old Street, E.C.	9·0	8·2	7·6	7·5	7·3	7·2	7·2	*7·0*	*7·0*	7·2	8·3	8·5	7·7
Norwood	7·9	7·2	6·4	6·5	6·3	6·3	6·2	6·3	*5·9*	6·3	7·6	7·2	6·7
Addington	7·9	7·6	7·0	7·0	6·7	6·3	*6·2*	*6·2*	6·3	6·9	8·0	7·6	7·0
Beddington	8·2	7·8	7·1	7·0	6·6	6·6	*6·3*	6·5	*6·3*	7·0	8·1	7·6	7·1
Marlborough	8·1	7·0	6·1	6·9	*5·5*	6·1	6·4	7·2	6·6	6·4	7·4	7·8	6·8
Harestock	7·7	7·0	6·6	6·2	*5·6*	6·3	6·2	6·1	5·8	6·3	7·3	7·4	6·5
Swarraton	8·0	7·5	7·0	6·9	*5·9*	6·5	6·7	7·0	6·5	6·7	7·8	7·7	7·0
Tunbridge Wells	7·5	7·1	6·4	6·3	6·2	6·1	6·0	*5·9*	*5·9*	6·6	7·7	7·2	6·6
Margate	7·7	7·5	6·4	6·4	6·6	6·6	*6·0*	*6·0*	6·3	7·0	7·6	7·7	6·8
Eastbourne	7·4	7·3	6·1	6·4	6·4	6·5	*5·9*	6·0	5·7	6·4	7·5	7·1	6·6
Brighton	6·6	6·2	5·4	5·5	5·1	5·4	5·1	5·1	4·7	5·7	6·8	6·6	5·7
Worthing	7·3	6·7	6·2	6·0	5·8	6·1	5·9	5·7	*5·4*	6·1	7·1	7·0	6·3
Portsmouth	6·8	6·4	5·8	5·6	*4·8*	5·4	5·4	5·3	5·2	5·7	6·8	6·7	5·8
Ventnor	6·6	6·5	5·6	5·4	*5·0*	5·4	5·4	5·9	5·4	5·9	6·6	6·3	5·8
Weymouth	6·6	6·3	5·8	5·6	*5·1*	5·3	5·9	5·7	5·6	6·1	6·8	7·0	6·0
England, N.W.													
Scaleby	7·6	7·4	6·9	6·6	*6·5*	6·6	7·1	7·3	6·8	6·6	7·6	7·3	7·0
Appleby	7·8	7·6	6·9	6·8	*6·5*	6·6	7·4	7·3	7·2	7·2	8·1	8·2	7·3
Seathwaite	7·4	*6·6*	6·9	6·9	7·0	7·0	7·3	7·3	7·1	7·5	7·8	7·6	7·2
Bolton	8·1	8·0	7·2	6·8	*6·6*	6·8	7·1	7·5	7·0	7·5	8·5	8·4	7·5
Macclesfield	7·7	7·1	6·6	*6·3*	6·4	6·4	7·3	7·1	6·4	6·9	7·6	7·7	7·0
Northwich	...	...	...	...	...	...	...	...	...	...	...	...	...
Chester	7·3	7·2	6·7	*6·5*	*6·5*	6·9	6·8	7·2	7·1	7·0	7·4	7·6	7·0
Blackpool	6·9	6·7	5·9	5·9	*5·0*	5·2	5·5	6·0	6·2	6·5	7·2	7·5	6·2
Llandudno	6·2	5·9	5·6	5·2	*5·1*	5·2	5·7	6·3	5·7	6·0	6·2	6·0	5·8

TABLE VII.—MEAN AMOUNT OF CLOUD (0–10) AT 9 A.M.—1891–1900—*continued.*

STATION.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, S.W.													
Aberystwith .	7·0	6·6	6·6	*5·8*	*5·8*	6·0	7·0	7·2	6·6	6·6	7·1	7·1	6·6
Gwernyfed Park .	7·7	7·0	6·1	5·9	*5·3*	5·4	5·8	6·4	6·5	7·3	7·9	7·9	6·6
Weston-super-Mare	7·5	6·8	6·2	6·3	*5·5*	6·1	6·3	6·5	6·2	6·7	7·6	7·5	6·6
Ilfracombe . .	7·6	7·0	6·4	6·1	*5·4*	5·6	6·4	6·7	6·3	6·8	7·5	7·9	6·6
Cullompton . .	7·2	7·0	6·3	5·7	*5·4*	5·5	6·4	6·5	6·1	6·4	7·6	7·2	6·4
Castle Hill . .	7·6	7·1	6·7	6·6	*6·2*	6·5	7·1	7·2	6·8	7·0	7·6	7·9	7·0
Ashburton . .	6·8	6·9	5·9	5·9	*5·5*	5·7	5·7	6·1	5·7	6·4	7·0	7·3	6·2
Princetown . .	7·7	7·5	6·6	6·3	*6·0*	*6·0*	6·2	6·9	6·3	7·2	7·6	8·0	6·9
Rousdon . .	6·8	6·8	6·1	6·4	*5·8*	6·3	6·5	6·5	*5·8*	6·6	7·0	7·1	6·5
Sidmouth . .	7·1	6·9	6·4	6·0	*5·6*	6·0	6·1	6·3	5·7	6·5	7·1	7·3	6·4
Torquay . .	6·7	6·5	5·6	5·5	*5·1*	5·4	5·4	5·9	5·6	6·2	6·9	7·0	6·0
Newquay . .	6·9	6·8	6·4	6·2	*5·7*	5·9	6·3	6·2	6·1	6·6	6·7	7·5	6·4
Falmouth . .	6·9	6·6	6·3	6·0	*5·5*	5·8	6·4	6·1	6·0	6·6	7·0	7·3	6·4
IRELAND													
Londonderry .	8·1	7·6	7·4	7·4	*7·3*	7·6	8·3	8·3	7·4	7·7	8·0	8·1	7·8
Ardgillan . .	7·1	7·3	6·4	6·9	6·8	6·8	7·7	7·4	*6·2*	6·5	7·0	7·2	6·9
Dublin . .	6·5	6·7	5·8	6·3	6·1	6·0	7·0	6·6	*5·7*	*5·7*	6·4	6·4	6·3
Killarney . .	7·3	7·5	6·9	7·0	*6·6*	7·0	7·8	7·6	*6·6*	*6·6*	7·1	7·8	7·2
CHANNEL ISLANDS													
Guernsey . .	7·5	6·7	6·2	5·9	5·6	5·6	*5·5*	5·9	5·8	6·5	7·0	7·1	6·3

Bennington, Beddington, Tunbridge Wells, Chester, and Castle Hill 7·0, Old Street, E.C., Appleby, and Princetown 7·2, Gwernyfed Park 7·3, Seathwaite and Bolton 7·5, Wakefield and Churchstoke 7·6, Londonderry 7·7, and Ravensthorpe 8·1.

I wish to emphasise the fact that the above remarks refer to the amount of cloud at 9 a.m. only.

Rainfall.

Before commencing to discuss this branch of our subject I should like to say that two stations have especially caused me great difficulty. The one station is Ilfracombe, and the other is Aberystwith. I will first deal with Ilfracombe. On February 21, 1894, Mr. Marriott read a paper on "Comparative Observations with two Sets of Instruments at Ilfracombe, North Devon, during 1893" (*Quarterly Journal*, Vol. XX. p. 164), and in it he gives the following table with respect to the Rainfall:—

Months.	Snowdon Gauge, 1 foot.	Old Gauge, 9 feet.	Difference.
	in.	in.	%
January . . .	2·57	1·99	− 23
February . .	5·62	4·44	− 21
March . . .	0·52	0·41	− 21
April . . .	0·22	0·17	− 23
May . . .	2·75	2·51	− 9
June . . .	1·10	0·93	− 15
July . . .	5·15	4·40	− 15
August . . .	2·13	1·75	− 18
September . .	3·01	2·37	− 21
October . . .	5·14	4·02	− 22
November . .	2·63	2·00	− 24
December . .	6·27	5·09	− 19
Year . .	37·11	30·08	− 19

This table revealed a serious state of things, but I have had no option. Up to December 1893 the observations of the old gauge were continued and then were stopped, and those of the new gauge were printed in their place from January 1893. I have, therefore, adopted Mr. Marriott's percentages, and calculated from the old gauge what the observations of the new gauge for the years 1891 and 1892 would have been if such gauge had been in existence. With respect to Aberystwith I have been in still greater difficulty. I extract the following from page 5 of the Introduction to the *Meteorological Record*, 1896 (Vol. XVI.): "In September 1895 a new rain gauge was placed in the Medical Officer's garden in the town. The records of this gauge confirm the opinion previously held that the gauge in the Castle grounds recorded too small an amount, the exposure being too bleak. From a comparison of two months' rainfall it appears that the gauge in the Castle grounds has received 79 per cent of that received by the town gauge. From January 1896 the results from the town gauge have been printed in the place of those from the Castle gauge." The two gauges have fortunately been working together since January 1896, and I have, therefore, constructed the following table from the figures supplied by Mr. Marriott :—

Year.	January.		February.		March.		April.		May.	
	Castle.	Town.	Castle.	Town.	Castle.	Town.	Castle.	Town.	Castle.	Town.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1896	1·45	1·85	0·73	0·90	3·11	4·12	0·90	1·24	0·34	0·47
1897	1·09	1·29	2·90	3·63	3·24	4·27	2·38	3·14	1·42	1·77
1898	3·67	4·55	1·72	2·33	1·06	1·20	1·63	2·22	2·45	3·02
1899	3·66	5·19	1·83	2·21	0·95	1·45	2·29	3·11	3·02	3·28
1900	2·88	3·65	2·27	2·51	0·51	0·63	1·57	2·00	1·78	2·18
Total .	12·75	16·53	9·45	11·58	8·87	11·67	8·77	11·71	9·01	10·72
Per Cent	77	100	82	100	76	100	75	100	84	100

Year.	June.		July.		August.		September.		October.	
	Castle.	Town.	Castle.	Town.	Castle.	Town.	Castle.	Town.	Castle.	Town.
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
1896	1·58	1·72	2·39	2·81	3·61	4·30	4·25	5·71	2·84	3·68
1897	1·59	2·04	2·05	2·27	2·70	3·29	3·86	5·02	1·57	1·81
1898	1·68	1·94	1·91	2·39	4·45	6·13	1·28	1·62	4·03	4·61
1899	2·43	2·72	1·95	2·22	2·58	2·89	2·64	3·72	2·93	3·66
1900	2·17	2·84	1·82	2·17	4·44	6·13	1·54	2·45	4·01	5·74
Total .	9·45	11·26	10·12	11·86	17·78	22·74	13·57	18·52	15·38	19·50
Per Cent	84	100	85	100	78	100	73	100	79	100

Year.	November.		December.		Year.	
	Castle.	Town.	Castle.	Town.	Castle.	Town.
	in.	in.	in.	in.	in.	in.
1896	0·88	1·09	4·31	5·39	26·39	33·28
1897	2·78	3·33	2·19	3·28	27·77	35·14
1898	2·81	3·53	4·12	5·62	30·81	39·16
1899	1·34	2·13	2·28	2·82	27·90	35·40
1900	3·86	4·56	2·69	4·20	29·54	39·06
Total .	11·67	14·64	15·59	21·31	142·41	182·04
Per Cent	80	100	73	100	78	100

This result seemed to me so startling that I consulted Mr. Marriott and Dr. Mill. Mr. Marriott recommended me to make use of these percentages, and to interpolate for the five years, 1891-95, in order to get an approximate value for the town gauge. Dr. Mill, whose opinion agreed with my own, did not favour interpolation. He mentioned Sir Pryse Pryse's gauge at Goggerddan, which is in a valley about three miles east-north-east of Aberystwith, and I have extracted the annual figures from the *British Rainfall*:—

	in.
1896	41·76
1897	45·45
1898	50·95
1899	44·41
1900	48·56
Total .	231·13

NOTE.—All the three gauges are 1 foot above the ground and the heights of the stations above sea-level are—Castle gauge = 59 feet; Town gauge = 15 feet; Goggerddan gauge = 80 feet. The percentages are as follows—Castle gauge = 62; Town gauge = 79; Goggerddan gauge = 100.

With these startling figures before me, it seems to me that I have no option but to take the observations of the Castle gauge, which are complete for the ten years, and give them as representing the town, but expressly stating that they are from the Castle gauge, and that a short distance away the rainfall is much heavier.

If we now turn to Table VIII., the annual column, we find that there are nine stations with an annual average of 40 ins. and above, and they are in order: Londonderry 40·38 ins., Falmouth 41·25 ins., Bolton 41·56 ins., Castle Hill 42·76 ins., Buxton 49·03 ins., Ashburton 51·03 ins., Killarney 56·10 ins., Princetown 73·78 ins., and Seathwaite 133·05 ins. It will be noticed that not one of these stations is nearer the meridian of Greenwich than about 2° W. long. A different state of affairs is, however, revealed if we take the average of 25 ins. and below, which includes sixteen stations fairly well distributed, and they are in order: Beddington 24·76 ins., Burghill 24·50 ins., Ravensthorpe 24·41 ins., Regent's Park 23·96 ins., Bennington 23·84 ins., Norwood 23·82 ins., Lowestoft 23·64 ins., Hodsock 23·26 ins., Lincoln 23·20 ins., Thurlow 23·19 ins., Margate 23·06 ins., Aspley Guise 22·80 ins., Old Street, E.C., 22·51 ins., Halstead 22·20 ins., Chelmsford 21·64 ins., and Wryde 21·27 ins. Here Burghill is the most westerly station, being about 3° W. long., and Lowestoft and Margate the most easterly stations, viz. about 1° E. long.

If now we turn to the monthly columns, we find in *January* twelve stations with a mean amount of 3·00 ins. and above, and they are in order: Cullompton 3·15 ins., Ilfracombe 3·26 ins., Londonderry 3·30 ins., Newquay 3·44 ins., Bolton 3·47 ins., Castle Hill 3·58 ins., Falmouth 4·21 ins., Buxton 4·65 ins., Ashburton 5·12 ins., Killarney 5·23 ins., Princetown 7·47 ins., and Seathwaite 12·76 ins. It will be noticed that all these stations are in the west. The stations with 2·00 ins. and below number eighteen, and are in order: Cheltenham 2·00 ins., Lincoln 1·88 ins., Regent's Park 1·85 ins., Lowestoft and Addington 1·83 ins., Wakefield 1·82 ins., Rounton and Beddington 1·80 ins., Margate 1·78 ins., Aspley Guise and Old Street, E.C., 1·76 ins., Wryde 1·75 ins., Hodsock 1·72 ins., Bennington and Norwood 1·70 ins., Halstead 1·63 ins., Thurlow 1·60 ins., and Chelmsford 1·58 ins.

TABLE VIII.—MEAN RAINFALL 1891–1900.

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, N.E.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Rothbury	2·77	2·79	2·76	*2·00*	2·07	2·34	2·77	3·34	2·38	**4·92**	3·00	3·20	34·34
Ushaw	2·16	1·80	1·86	*1·70*	1·92	2·39	2·52	3·05	1·97	**3·99**	2·32	2·44	28·12
Rounton	1·80	1·48	1·67	*1·45*	1·72	2·33	2·49	3·19	1·68	**3·44**	2·03	1·84	25·12
Scarborough	2·29	1·86	1·62	*1·41*	1·93	2·21	2·34	2·92	1·77	**3·70**	2·20	2·28	26·53
Driffield	2·19	1·96	1·79	1·74	1·90	2·32	1·94	2·73	*1·66*	**3·72**	2·64	2·73	27·32
Lincoln	1·88	1·45	*1·24*	1·48	1·94	2·30	2·18	2·32	1·59	**2·84**	1·84	2·14	23·20
ENGLAND, E.													
Hillington	2·36	1·70	1·67	*1·46*	1·81	2·05	2·51	2·99	2·11	**3·37**	2·45	2·59	27·07
Lowestoft	1·83	*1·39*	1·40	1·46	1·60	2·07	2·34	2·81	1·58	**2·95**	2·15	2·06	23·64
Wryde	1·75	1·35	*1·07*	1·15	1·55	1·57	1·78	2·70	1·76	**2·90**	1·90	1·79	21·27
Thurlow	1·60	1·36	1·48	*1·21*	1·41	2·35	2·64	**2·80**	1·84	2·53	1·96	2·01	23·19
Halstead	1·63	1·54	1·49	*1·19*	1·38	1·87	**2·47**	2·45	1·71	2·30	2·07	2·10	22·20
Chelmsford	1·58	1·51	1·51	1·14	*1·12*	1·96	2·00	2·24	1·75	**2·54**	2·11	2·18	21·64
Bennington	1·70	1·63	1·54	*1·23*	1·73	1·72	2·06	2·67	1·93	**2·91**	2·34	2·38	23·84
MIDLAND CO.													
Wakefield	1·82	1·91	*1·40*	1·66	1·69	2·55	2·60	2·88	1·62	**3·25**	1·80	2·44	25·62
Hodsock	1·72	1·70	*1·20*	1·51	1·88	2·33	2·23	2·21	1·59	**2·81**	1·88	2·20	23·26
Buxton	4·65	3·80	3·65	*3·03*	3·04	3·52	3·50	4·71	3·83	5·11	3·80	**6·39**	49·03
Belper	2·77	2·25	*1·80*	2·00	2·16	2·96	2·54	2·97	2·13	3·06	2·62	**3·51**	30·77
Cheadle	2·81	2·11	*1·81*	1·98	2·05	2·81	2·69	3·38	2·49	3·00	2·41	**3·41**	30·95
Churchstoke	2·60	2·18	1·78	1·73	2·26	2·17	*1·64*	2·57	2·29	3·64	2·53	**3·70**	29·09
Malvern	2·40	1·97	*1·44*	1·46	2·12	1·85	1·92	2·84	2·10	**3·10**	2·43	2·95	26·58
Burghill	2·24	1·91	*1·28*	1·32	2·01	1·76	1·86	2·41	1·82	**2·84**	2·21	**2·84**	24·50
Ross	2·32	2·00	*1·48*	1·53	2·07	1·85	1·94	2·63	2·12	**3·45**	2·39	2·96	26·74
Cheltenham	2·00	2·02	*1·46*	*1·46*	1·74	1·59	1·95	**3·06**	1·97	2·88	2·42	2·73	25·28
Ravensthorpe	2·05	1·67	1·41	*1·37*	1·57	1·82	2·09	2·74	1·94	**3·14**	2·18	2·43	24·41
Aspley Guise	1·76	1·49	1·25	*1·09*	1·73	1·56	2·25	2·79	1·69	**2·85**	2·20	2·14	22·80
Berkhamsted	2·18	1·98	1·73	*1·36*	1·44	1·74	2·05	2·94	1·96	**3·51**	2·86	2·82	26·57
ENGLAND, S.													
Regent's Park	1·85	1·72	1·62	*1·28*	1·41	1·51	2·08	2·50	2·01	**3·13**	2·43	2·43	23·97
Old Street, E.C.	1·76	1·63	1·52	*1·19*	1·27	1·39	1·96	2·36	1·92	**3·03**	2·25	2·23	22·51
Norwood	1·70	1·67	1·58	*1·23*	1·42	1·75	2·21	2·48	1·85	**3·13**	2·52	2·28	23·82
Addington	1·83	1·80	1·76	*1·19*	1·55	1·95	2·15	2·41	2·09	**3·53**	2·97	2·66	25·89
Beddington	1·80	1·76	1·72	*1·20*	1·43	1·71	2·15	2·32	1·97	**3·26**	2·86	2·58	24·76
Marlborough	2·26	2·22	1·91	1·74	*1·60*	2·10	2·07	2·97	2·31	**3·72**	3·29	3·32	29·51
Harestock	2·62	2·31	2·16	*1·63*	1·66	1·85	2·32	3·05	2·57	**4·06**	3·88	3·69	31·80
Swarraton	2·50	2·36	2·02	*1·48*	1·60	1·88	2·21	2·69	2·49	**4·22**	3·63	3·53	30·61
Tunbridge Wells	2·64	2·23	2·20	*1·42*	1·54	2·02	2·06	2·33	2·46	**4·23**	3·64	3·43	30·20
Margate	1·78	1·61	1·48	*1·08*	1·55	1·87	2·13	2·30	1·69	**3·01**	2·34	2·22	23·06
Eastbourne	2·44	2·16	1·93	1·57	*1·33*	1·80	2·62	2·50	3·11	**4·31**	3·34	3·31	30·42
Brighton	2·35	1·97	1·75	1·43	*1·26*	1·72	2·01	2·13	2·47	**3·91**	3·04	3·00	27·04
Worthing	2·25	1·91	1·57	1·29	*1·16*	1·59	2·19	1·92	2·42	**3·67**	3·17	2·65	25·79
Portsmouth	2·34	2·03	1·68	1·31	*1·19*	1·63	2·28	2·28	2·54	**3·75**	3·43	2·80	27·26
Ventnor	2·66	2·09	1·77	1·46	*1·44*	1·90	2·03	1·93	2·63	**3·94**	3·31	2·95	28·05
Weymouth	2·49	2·09	1·86	1·53	*1·44*	1·58	1·90	1·88	2·29	3·15	3·43	**3·60**	27·14
ENGLAND, N.W.													
Scaleby	2·26	2·31	1·98	*1·75*	2·27	3·00	2·99	**4·82**	3·22	3·54	2·70	3·47	34·31
Appleby	2·77	2·82	2·42	*1·87*	2·12	2·56	3·24	4·00	3·14	4·10	3·19	**4·20**	36·43
Seathwaite	12·79	11·27	10·05	7·12	6·21	*6·14*	7·24	14·54	12·80	13·09	13·46	**18·34**	133·05
Bolton	3·47	2·95	2·69	*2·34*	2·36	2·96	3·02	4·94	3·93	4·46	3·40	**5·04**	41·56
Macclesfield	2·60	2·29	2·20	*2·13*	2·33	3·12	2·78	**3·96**	2·68	3·66	2·42	3·70	33·87
Northwich	2·31	2·00	*1·67*	1·83	2·10	2·80	2·35	**3·84**	2·54	3·29	2·25	3·20	30·18
Chester	2·05	1·68	*1·46*	1·52	1·91	2·54	2·37	**3·43**	2·33	3·35	2·12	2·60	27·36
Blackpool	2·54	2·24	1·87	*1·86*	1·99	2·33	2·24	**4·38**	3·12	4·16	3·20	3·59	33·52
Llandudno	2·44	1·95	1·87	*1·84*	1·97	2·11	2·06	3·27	2·74	**4·62**	2·91	3·17	30·95

TABLE VIII.—MEAN RAINFALL 1891-1900—*continued.*

STATION.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
ENGLAND, S.W.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
Aberystwith .	2·23	1·55	*1·52*	1·53	1·79	1·83	2·34	3·32	2·45	**3·58**	2·42	3·03	27·59
Gwernyfed Park .	2·78	2·48	1·87	*1·64*	2·18	1·96	2·24	3·06	2·28	4·17	2·98	**4·22**	31·86
Weston-super-Mare	2·33	2·20	*1·42*	1·50	1·62	1·64	2·07	3·38	2·57	**3·96**	2·59	3·08	28·36
Ilfracombe . .	3·26	3·16	2·27	2·07	1·99	*1·72*	2·57	3·92	3·46	**5·26**	4·01	5·22	38·91
Cullompton . .	3·15	2·71	2·10	1·89	2·00	*1·83*	2·75	3·22	2·45	3·96	3·71	**4·37**	34·14
Castle Hill . .	3·58	3·31	2·80	2·29	2·36	*1·97*	3·20	4·31	3·75	5·38	4·34	**5·47**	42·76
Ashburton . .	5·12	4·34	3·67	2·68	2·60	2·62	*2·56*	3·96	3·22	6·36	5·98	**7·92**	51·03
Princetown . .	7·47	6·32	4·90	4·54	*3·78*	3·88	4·50	6·57	4·84	7·75	8·28	**10·95**	73·78
Rousdon . .	2·96	2·33	2·06	·80	*1·61*	1·86	2·44	2·81	2·31	3·52	3·77	**4·12**	31·59
Sidmouth . .	2·96	2·28	2·07	1·72	*1·62*	1·79	2·27	3·19	2·11	3·41	3·47	**3·83**	30·72
Torquay . .	2·64	2·16	2·31	*1·69*	1·70	2·01	2·39	3·16	2·20	4·42	3·88	**4·79**	33·35
Newquay . .	3·44	2·55	1·98	·96	*1·56*	1·67	2·30	2·79	2·94	4·21	3·76	**4·86**	34·02
Falmouth . .	4·21	3·37	2·66	2·38	*1·74*	2·07	2·28	3·45	2·73	4·92	4·83	**6·61**	41·25
IRELAND.													
Londonderry .	3·30	2·94	3·03	*2·47*	2·70	3·11	3·27	4·08	3·30	4·26	3·43	**4·49**	40·38
Ardgillan . .	2·28	1·75	*1·56*	2·06	2·01	2·23	3·11	**4·27**	1·97	2·77	2·74	2·87	29·62
Dublin . .	2·34	1·67	*1·55*	1·73	2·10	2·12	3·01	**3·66**	1·92	2·72	2·76	2·40	27·98
Killarney . .	5·23	4·64	3·57	3·51	*2·62*	3·04	3·62	5·37	3·75	5·96	6·36	**8·43**	56·10
CHANNEL ISLANDS.													
Guernsey . .	2·76	2·10	1·92	1·93	*1·71*	1·78	2·00	2·37	2·94	**4·31**	3·53	4·07	31·42

In *April* we have a smaller rainfall, and the stations with the highest rainfall do not necessarily seem to be in the west. There are fourteen of such stations with a rainfall of 2·00 ins. and above, and they are in order: Rothbury and Belper 2·00 ins., Ardgillan 2·06 ins., Ilfracombe 2·07 ins., Macclesfield 2·13 ins., Castle Hill 2·29 ins., Bolton 2·34 ins., Falmouth 2·38 ins., Londonderry 2·47 ins., Ashburton 2·68 ins., Buxton 3·03 ins., Killarney 3·51 ins., Princetown 4·54 ins., and Seathwaite 7·12 ins. There are eleven stations with an average monthly rainfall of 1·25 ins. and below, and they are: Bennington and Norwood 1·23 ins., Thurlow 1·21 ins., Beddington 1·20 ins., Halstead, Old Street, E.C., and Addington 1·19 ins., Wryde 1·15 ins., Chelmsford 1·14 ins., Aspley Guise 1·09 ins., and Margate 1·08 ins.

In *July*, though there is a somewhat large increase in the rainfall, there are only ten stations with a rainfall over 3·00 ins., and they are in order: Dublin 3·01 ins., Bolton 3·02 ins., Ardgillan 3·11 ins., Castle Hill 3·20 ins., Appleby 3·24 ins., Londonderry 3·27 ins., Buxton 3·50 ins., Killarney 3·62 ins., Princetown 4·50 ins., and Seathwaite 7·24 ins. All these stations are west of about 2° W. long. There are eleven stations with a rainfall of 2·00 ins. and under, and they are: Chelmsford and Guernsey 2·00 ins., Old Street, E.C., 1·96 ins., Cheltenham 1·95 ins., Driffield and Ross 1·94 ins., Malvern 1·92 ins., Weymouth 1·90 ins., Burghill 1·86 ins., Wryde 1·78 ins., and Churchstoke 1·64 ins.

In *October*, one of the wettest months of the year, we have a rainfall of 4·50 ins. and above at ten stations, and they are in order as follows: Llandudno 4·62 ins., Rothbury and Falmouth 4·92 ins., Buxton 5·11 ins., Ilfracombe 5·26 ins., Castle Hill 5·38 ins., Killarney 5·96 ins., Ash-

TABLE IX.—No. of Rainy Days (0·01 In. and upwards)—1891–1900.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
England, N.E.													
Rothbury	16	12	13	12	13	12	12	15	13	17	17	18	170
Ushaw	19	14	16	14	14	14	13	17	12	17	18	17	185
Rounton	18	14	16	14	15	15	14	17	14	18	18	16	189
Scarborough	19	13	14	12	15	13	12	16	11	20	18	16	179
Driffield	20	15	17	13	14	13	12	16	13	19	18	18	188
Lincoln	21	15	15	13	13	13	13	17	12	21	20	20	193
England, E.													
Hillington	21	16	17	13	13	14	13	16	13	22	19	21	198
Lowestoft	20	12	15	12	12	12	13	15	11	18	15	15	170
Wryde	16	11	12	11	11	12	11	16	10	16	15	15	156
Thurlow	18	13	15	13	12	13	12	17	11	18	15	17	174
Halstead	17	13	13	11	11	11	12	14	10	15	13	16	156
Chelmsford	16	13	13	11	10	10	11	13	10	16	15	15	153
Bennington	18	15	15	12	12	12	12	14	12	19	18	20	179
Midland Co.													
Wakefield	15	10	12	11	12	11	11	15	11	14	13	14	149
Hodsock	18	13	15	13	13	13	13	15	12	18	17	17	177
Buxton	21	16	18	16	15	15	16	19	16	18	18	20	208
Belper	19	15	15	13	14	13	13	17	14	18	16	19	186
Cheadle	19	15	15	13	13	13	13	18	13	17	16	20	185
Churchstoke	17	13	15	14	14	12	12	17	15	18	15	20	182
Malvern	16	13	12	13	12	11	10	16	12	16	16	17	164
Burghill	16	12	13	14	12	11	12	16	12	16	17	18	169
Ross	17	13	14	14	13	13	14	18	14	18	17	19	184
Cheltenham	19	14	14	13	13	12	12	17	13	19	17	19	182
Ravensthorpe	17	11	12	11	12	12	13	15	11	15	15	16	160
Aspley Guise	16	11	14	11	12	11	12	16	12	17	15	18	165
Berkhamsted	19	13	14	13	11	11	12	16	12	17	15	19	172
England, S.													
Regent's Park	17	13	12	11	11	11	10	14	11	16	14	15	155
Old Street, E.C.	17	13	13	13	11	11	11	15	11	16	14	17	162
Norwood	17	13	14	12	12	12	11	16	11	17	15	18	169
Addington	18	13	14	13	12	12	11	17	14	20	17	19	180
Beddington	17	13	12	11	11	11	10	15	13	15	15	16	159
Marlborough	19	13	14	13	14	12	14	15	13	18	18	19	182
Harestock	18	14	13	13	11	13	12	15	14	17	16	20	176
Swarraton	17	13	14	12	11	10	12	16	14	17	17	20	173
Tunbridge Wells	19	14	13	12	11	12	12	15	13	17	17	19	174
Margate	19	13	15	11	12	10	11	13	12	17	18	18	169
Eastbourne	18	13	13	11	10	10	11	15	12	18	17	19	167
Brighton	17	13	14	11	10	11	10	14	12	17	16	18	163
Worthing	15	13	12	11	9	10	9	13	11	17	15	18	153
Portsmouth	15	12	13	12	9	11	10	13	12	16	16	18	157
Ventnor	15	12	13	11	11	11	9	13	11	17	15	18	156
Weymouth	14	11	13	11	9	10	10	12	11	15	14	18	148
England, N.W.													
Scaleby	19	16	17	15	14	15	16	20	18	19	19	22	210
Appleby	20	16	16	15	14	15	15	19	18	19	18	22	207
Seathwaite	20	17	18	16	16	15	18	21	19	18	19	22	219
Bolton	21	16	17	15	15	15	16	19	18	19	17	22	210
Macclesfield	19	14	15	12	14	14	15	18	15	17	16	19	188
Northwich	18	15	15	14	15	15	14	20	16	18	17	20	197
Chester	18	14	14	14	14	13	14	18	15	18	16	19	187
Blackpool	18	15	15	13	12	13	12	18	14	19	16	20	185
Llandudno	17	15	14	14	13	14	13	17	16	19	16	20	188

TABLE IX.—No. of Rainy Days (0·01 In. and upwards)—1891–1900—*continued.*

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
England, S.W.													
Aberystwith .	**20**	15	15	14	*13*	*13*	15	16	16	18	17	**20**	192
Gwernyfed Park .	21	15	15	15	13	*11*	14	18	15	19	18	**22**	196
Weston-super-Mare	16	12	11	11	11	*10*	*10*	15	14	15	14	**18**	157
Ilfracombe . .	18	14	13	13	12	*11*	12	16	15	18	16	**19**	177
Cullompton . .	19	15	14	12	12	*10*	13	16	14	18	16	**21**	180
Castle Hill . .	21	17	18	16	*14*	15	17	19	18	21	19	**24**	219
Ashburton . .	17	14	14	12	12	*11*	13	15	14	19	17	**22**	180
Princetown . .	21	15	16	14	13	*11*	14	19	16	20	17	**23**	199
Rousdon . .	16	13	14	13	*11*	*11*	13	15	13	16	15	**20**	170
Sidmouth . .	20	15	15	14	13	*12*	14	18	13	19	18	**21**	192
Torquay . .	17	12	13	12	*10*	11	11	14	13	16	15	**20**	164
Newquay . .	20	14	15	14	12	*11*	13	16	14	19	18	**23**	189
Falmouth . .	20	15	14	15	*11*	*11*	13	16	14	20	18	**22**	189
Ireland.													
Londonderry .	23	18	21	18	*17*	18	19	23	20	23	21	**24**	245
Ardgillan . .	**21**	*13*	16	14	*13*	*13*	14	17	14	15	16	19	185
Dublin . .	**20**	15	15	16	*13*	15	15	19	15	16	16	**20**	195
Killarney . .	20	18	16	18	*16*	*16*	18	21	17	19	20	**24**	223
Channel Islands.													
Guernsey . .	20	13	15	13	11	10	*9*	13	14	19	18	**21**	176

burton 6·36 ins., Princetown 7·75 ins., and Seathwaite 13·09 ins. These stations, with the exception of Rothbury, are in the west. The stations with a rainfall of 3·00 ins. and below number thirteen, and are in order: Lowestoft 2·95 ins., Bennington 2·91 ins., Wryde 2·90 ins., Cheltenham 2·88 ins., Aspley Guise 2·85 ins., Lincoln and Burghill 2·84 ins., Hodsock 2·81 ins., Ardgillan 2·77 ins., Dublin 2·72 ins., Chelmsford 2·54 ins., Thurlow 2·53 ins., and Halstead 2·30 ins.

With respect to the Number of Rainy Days I do not propose to say much. December appears to have the greatest number, and May the smallest. But with respect to the annual column I shall speak more at length. Weymouth has the smallest number, viz. 148, and Wakefield comes next with 149. Then in order between 151 and 160, we have Chelmsford and Worthing (153), Regent's Park (155), Wryde, Halstead, and Ventnor (156), Portsmouth and Weston-super-Mare (157), Beddington (159), and Ravensthorpe (160). Between 161 and 170 we have Old Street, E.C. (162), Brighton (163), Malvern and Torquay (164), Aspley Guise (165), Eastbourne (167), Burghill, Norwood, and Margate (169), Rothbury, Lowestoft, and Rousdon (170). Between 171 and 180 we have Berkhamsted (172), Swarraton (173), Thurlow and Tunbridge Wells (174), Harestock and Guernsey (176), Hodsock and Ilfracombe (177), Scarborough and Bennington (179), and Addington, Cullompton, and Ashburton (180). Between 181 and 190 there are Churchstoke, Cheltenham, and Marlborough (182), Ross (184) Ushaw, Cheadle, Blackpool, and Ardgillan (185), Belper (186), Chester (187), Driffield, Macclesfield, and Llandudno (188), and Rouston, Newquay, and Falmouth (189). Between 191 and 200 there are Aberystwith and Sidmouth (192), Lincoln (193), Dublin (195), Gwernyfed Park (196), Northwich (197), Hillington

(198), and Princetown (199). Between 201 and 210 there are Appleby (207), Buxton (208), and Scaleby and Bolton (210). And above 210 there are Seathwaite and Castle Hill (219), Killarney (223), and Londonderry (245).

In conclusion, I consider that the Society is to be congratulated on having such a body of disinterested and careful observers, who have provided such a large amount of admirable and trustworthy data relating to the climate of the British Isles, and that the observers deserve the thanks not only of the Society, but of all those who are engaged in studying the problems of the life and health of the people.

DISCUSSION

Mr. R. Inwards (Chairman) said that all must agree in thanking Mr. Bayard for his valuable paper. Few people could realise the amount of labour represented by these detailed investigations, and though the paper might not, at the first reading, wholly permeate the minds of those present, they would find it was one which might profitably be studied in the quiet of the home library.

Mr. W. Marriott expressed his thanks to Mr. Bayard for discussing the results from the Society's stations, published in the *Meteorological Record*. This was a work which he (Mr. Marriott) would like to have undertaken, but the time of the staff was so fully occupied that he was unable to do so. The Fellows would probably know that it had been his custom since 1884, when inspecting the stations of the Society, to take photographs showing the exposure of the instruments, etc. These were mounted in albums, which practically furnished a history of the stations. On looking through the tables given by Mr. Bayard, he was very pleased to see that the results agreed so well together. There was no doubt that the instrumental observations were reliable. The element of doubt would only enter into observations of estimation, such as the amount of cloud, and also the relative humidity values which were dependent upon the proper working of the wet-bulb thermometer. The Fellows would know that the wet-bulb thermometer was difficult to manage in frost. During the past winter he had himself lost the wet-bulb readings on two occasions, although he had two wet-bulb thermometers in use, and had taken special precautions to get them to work properly. This would show that the ordinary observer might perhaps be excused if his instrument did not always give proper readings during frost. Still the figures given in Mr. Bayard's tables showed that the results agreed remarkably well.

On looking through the temperature tables the influence of aspect and exposure was brought out markedly in a few cases; for instance, at Malvern the minimum temperatures were much higher than at surrounding stations. Those who were acquainted with Malvern would know that it was situated on the eastern slope of a high range of hills running nearly north and south, and was 500 or 600 feet above sea-level. It consequently had the full benefit of the sun in the early part of the day, and at night the cold air slid down the steep slope, and consequently the effects of radiation were not so great as at stations on level ground.

With regard to the Aberystwith rainfall, he did not agree with Mr. Bayard in taking the Castle gauge results as representative of the rainfall of that town. The Castle gauge, along with the thermometer screen, etc., were placed within a railed enclosure on a very bleak and open spot close to the cliff: these were exposed to the full force of the wind from the South, West, and North. It had

been apparent to him, some years ago, that the exposure was not satisfactory for a rain-gauge, and he had endeavoured to get a second gauge started in another part of the town. The observer, Dr. A. Thomas, ultimately placed a rain-gauge in his garden, the results from which he (Mr. Marriott) believed to be much more representative of the town of Aberystwith than those of the Castle gauge. He regretted that Mr. Bayard had brought in the rainfall at Gogerddan, as that was by no means representative of Aberystwith, and the rainfall was much heavier. Just a year ago the observer at Aberystwith had called his attention to a map, published in the *Daily Mail*, showing "Holiday Resorts with the Least Rainfall," in which the rainfall at Aberystwith was shown to be the heaviest of all the stations in the three months, July, August, and September. The values given were greatly in excess of the average rainfall at Aberystwith, and he (Mr. Marriott) had recently found that the compiler of the map had used the Gogerddan returns, and so had credited Aberystwith with more than its proper amount of rain.

Mr. Marriott exhibited charts of the relative humidity for January and July, which he had prepared from the figures given in Table IV. It was clearly seen, from the January chart, that the greatest humidity prevailed over the eastern parts of the country, from the Humber to the Severn, except along the South Coast, the driest part being the Western Coast of Wales. In July the greatest dryness was over London and practically the whole of the Home Counties, and the greatest humidity was in the Northern and in the South-western parts of the country. He also exhibited maps showing the amount of cloud in the same manner. From these it appeared that in January the greatest amount of cloud was over the Thames valley and the manufacturing districts of Lancashire, London itself being the most cloudy of all, while the least amount of cloud was along the South Coast. In July the greatest amount of cloud was over the North-western part of the country, excepting along the coast, while the districts with the least amount of cloud were the South Coast, and on the coasts of North Wales and Lancashire.

Mr. Marriott thought that the Society was greatly indebted to the observers for their devotion and perseverance in taking the observations so systematically, as without their help it would be impossible to prepare such valuable results on the climate of the British Isles as were given in Mr. Bayard's paper.

Dr. C. THEODORE WILLIAMS had found the paper exceedingly interesting, and that, like Mr. Bayard's previous paper on the subject, it helped to place British Meteorology on a broader basis. Doctors should feel particularly obliged, since health was largely dependent upon weather, and this paper supplied facts which must be of great service. One point was remarkable to note, viz. that temperature as well as rainfall is higher in the west than in the east of the British Islands, and this cannot but enforce the old theory of the influence of the Gulf Stream. When the whole of the papers on the subject have been published it may be presumed very useful results will be drawn, based upon a twenty years' average.

With regard to the Castle gauge at Aberystwith, mentioned by Mr. Marriott, it explained matters, now that he knew a second gauge had been instituted, as he had hitherto been puzzled to understand the rainfall returns. The Castle gauge was situated in a very bleak and exposed spot, and when a wild South-wester was blowing it must have been very trying for observers and detrimental to the results of that gauge.

Dr. H. R. MILL remarked that the paper whetted the appetite for more, and that the twenty years' averages would be looked forward to with attention. It was desirable that a long period should be covered in taking averages, and the comparison of Mr. Bayard's two papers would be particularly valuable. It would probably be as well to leave out the Channel Islands and Irish stations,

and confine the discussion to the climatology of England. In discussing the temperature observations, it would be an advantage to eliminate the effect of altitude: and if Mr. Bayard would add to his tables a column giving the temperatures reduced to sea-level, so much the better. Buxton and Princetown were extreme stations, mainly because of their elevation, but these and other anomalies would be smoothed out when the reduction was made. Cloud observations were, of course, less comparable than instrumental readings, as so much depended upon the personal equation. Wet-bulb observations also were difficult to make in certain circumstances. Mr. Marriott had mentioned these difficulties, and if he did not always succeed in obtaining good observations, who could?

With regard to rainfall, it was of great importance that there should be numerous stations if a full discussion were to be attempted. He did not suggest that the Castle gauge at Aberystwith registered the full amount of rain. At the same time the increase of rainfall is rapid and fairly uniform from the sea-coast towards the hills. He agreed with Mr. Marriott that the town gauge was better than the Castle gauge as representing Aberystwith. It was not good, however, to interpolate results for many years: and recognising that the record was too low, its use for comparative purposes could do no harm.

The January map exhibited by Mr. Marriott showed a striking agreement of relative humidity with geological formation, the whole of the dark area on the map (indicating highest humidity) being over those parts of the country where nearly level plains of clay covered a large part of the surface and tended to retain moisture on the surface. The regions of low relative humidity, on the other hand, though subject to heavy rainfall, were made up of steep slopes allowing a rapid run-off.

Mr. C. HARDING said that Mr. Bayard's paper was a great help to the Society, and that the results of the twenty years' averages must be of considerable value. He also suggested that the two papers should be produced in monthly succession. There was remarkable uniformity in the maximum temperature in July, and the minimum month by month exactly where expected, and the rainfall appeared just as accurate. The maximum of rain generally occurred in October, but sometimes it occurred in the North-west in January. These matters proved the general accuracy of the observations.

Mr. J. HOPKINSON pointed out that Mr. Bayard's paper was a complete justification of the continuance of the *Meteorological Record* in its present form, and that this would doubtless be more fully appreciated when the record of twenty years was dealt with, as promised. Divergences between the temperature, as determined by 9 a.m. readings, and by the mean of the minimum and maximum, might be due to slight differences in the time of observation, for we might not all observe punctually, and, moreover, some may use Greenwich time, while local time only would give strictly comparable results. He thought that it was more difficult to determine, in certain hazy states of the atmosphere, whether the sky should be reported as clear or overcast, than it was to determine the proportion of sky covered when distinct clouds were visible. The high relative humidity of Buxton and Princetown might be accounted for by the heavy and frequent rainfall of the Peak district and Dartmoor. Anomalies in the number of rainy days were, he thought, often due to different methods of observers; for instance, in Hertfordshire, taking only stations where other meteorological observations were made daily, on the average of twelve years over forty more days of rain per annum were recorded at Bennington and St. Albans (his own station) than at New Barnet, although at the latter place the rain was read to thousandths of an inch, and he had taken a fall of at least ·005 inch as constituting a rainy day. He considered that great thanks were due to Mr. Bayard for the labour which he had bestowed upon his paper.

Mr. F. C. BAYARD, in reply, said, with reference to the question about rainy days raised by Mr. Hopkinson, he noticed that, as a general rule, the very fact of taking temperature and other observations seemed to make observers more careful in looking to their rain-gauges, whereas those who observed rain-gauges only were not always so careful to record every day's readings, and this might account for some of the differences in the returns. Dr. Mill's suggestion about the Guernsey and Irish stations should have consideration, but he (Mr. Bayard) had previously made up his mind to reduce the temperature observations to sea-level, and he had given the values in their present form only for those who might so want to use them.

Solar and Meteorological Changes.—Sir Norman Lockyer and Dr. W. J. S. Lockyer recently communicated a paper "On some Phenomena which suggest a Short Period of Solar and Meteorological Changes" to the Royal Society. They say that in continuation of the inquiries referred to in a former paper on Indian rainfall and solar activity,[1] attention has more recently been devoted to an examination of the variations of pressure over the Indian and other areas.

1. It is well known that in India during the summer months (April to September) and during the winter months (October to March) low and high pressures respectively prevail. In the case of the latter, the pressure is found to exhibit very remarkable and definite variations, and is in excess every $3\frac{1}{2}$ years on the average, while at these times of excess of high pressure the low pressure during the other six months of the year is deficient; so that every $3\frac{1}{2}$ years or so the high pressure becomes higher, and the low pressure is not so low as usual.

2. Further, this short-period variation, which appears in the mean variation of pressure over the whole of India, is as well defined in the mean values for individual stations such as Bombay, Calcutta, Madras, Nagpur, etc.

3. The view that the variation of pressure in question over India and its neighbourhood is not due to local causes, but is produced by some external or extra-terrestrial action, is considerably strengthened by an examination of the pressure curve of a very distant station, such as Cordoba. Dealing with the pressure of Cordoba during the high-pressure months, April to September, the curve representing the variation from the mean from year to year is exactly the *inverse* of the curve representing the Bombay and other Indian pressures for the same months over the same period of time. The cause, therefore, which raises the mean value for the low-pressure months over the Indian area would appear to lower the mean value of high-pressure months at Cordoba simultaneously. In fact, we have a see-saw.

4. Further investigation shows that not only do the pressures of practically the whole Indian area exhibit variations from year to year which present very similar features, but that this is the case with other large areas. Thus, for instance, it is found that the yearly mean pressures for Brussels, Bremen, Oxford, Valencia, and Aberdeen (the only pressures that have been at present examined) are all remarkably similar in their variations from year to year, and it might almost be said that one curve, representing the variations from the normal, would approximately define the pressure at all these places.

The probable extra-terrestrial origin of these short-period variations led to a detailed examination of the records of the phenomena connected with solar spots and prominences, with a view to seeing whether similar variations indicating changes in the solar activity could be detected.

[1] See *Quarterly Journal of the Royal Meteorological Society*, vol. xxvii. p. 160.

5. A preliminary reduction of the Italian observations of prominences observed on the sun's limb since 1871 was first undertaken. The result of this inquiry indicates that, in addition to the main epochs of maximum and minimum of prominences, which coincide in time with those of maximum and minimum of the total spotted area, there are prominent subsidiary maxima and minima, having a similar short period and also coinciding in time.

6. Although these subsidiary prominence pulses are not distinctly duplicated in the curve representing the spotted area of the solar surface, it is to be noted that corresponding pulses are indicated in the curves which represent the change of latitude of spotted area from year to year; and in each case an increase in prominence activity is associated with a decrease of latitude of the spotted area.

7. A comparison of these solar data with those already referred to relating to terrestrial pressures suggests that these simultaneous outbursts of prominences and changes of the latitudes in which the spots occur about every $3\frac{1}{2}$ years are the true cause of the pressure changes; and that the varying intensity of solar activity during the sunspot period of eleven years produces an effect on the pressure and circulation of our atmosphere, thus affecting the whole globe meteorologically.

8. The close correspondence between the epochs of these subsidiary pressure variations and those representing prominence frequency, suggests not only their very close relationship, but that the terrestrial pressure quickly answers to the solar changes, while, so far as the work has gone, it would appear that rainfall and snowfall are subsequent effects.

9. It may be remarked that we have already obtained evidence showing that this short period variation is not the only one acting, but that the 11 year and 35 year periods apparently influence the short-period variations. But even this does not explain some anomalies already met with, and should the solar origin of these short-period pressure changes be subsequently confirmed, some of them not constant in all localities will have to be explained; and it is possible we may obtain in this way some new knowledge on the atmospheric circulation.

10. The period of time included in this survey begins generally with the establishment of the full records of the Indian Meteorological Department in 1875, and extends to 1895, when the regularity of the widened-line phenomena was broken, as stated in a previous communication.

In continuing the above researches we have plotted the percentage frequency of the solar prominences derived from the Italian observations for each 10° of solar latitude north and south of the equator. We find that the epochs of maximum prominence disturbance in the higher latitudes are widely different from those near the equator. The latter are closely associated with the epochs of maximum spotted area; the former occur both north and south at intervening times.

We have, then, two sets of strongly marked prominence outbursts occurring at intervals of between three and four years. Both sets are represented closely in the Indian pressure curves.

Weather Bureau, Queensland.—We learn that the Bureau, as a purely Government concern, ceased to exist on July 1 last, but that Mr. Clement L. Wragge has taken it over into his own hands as a private venture. He is to receive a subsidy from the Governments of Queensland, New South Wales, and Tasmania, to the total extent of £1000 per annum. He hopes, by the charges for the supply of Weather Forecasts to the press, etc., to be able to carry on the work successfully. He has started a weekly publication entitled *Wragge*, which is to be a "Meteorological, Geographical, and Popular Scientific Gazette for the people of the Southern Hemisphere," and also the "Official Journal of the Central Weather Bureau."

EARTH TEMPERATURE OBSERVATIONS RECORDED IN UPPER INDIA.

By W. L. DALLAS, Assistant Meteorological Reporter to the Government of India.

[Read June 18, 1902.]

EARTH temperatures have for several years past been recorded at three stations in Upper India, viz., Lahore, the capital of the Punjab; Dehra Dun, a station in the north-west of the North-Western Provinces; and at Jaipur, the capital of the native state of that name. At these three places there was no attempt at uniformity in the method of observations, as the readings were recorded at different depths and at different hours at all three stations, but the results are nevertheless worth discussion, and to a certain extent are comparable one with the other.

Lahore.

In 1885 the Observatory was removed to an open site in the immediate vicinity of the district jail, about 4 miles to the south of the city of Lahore. The Observatory is situated in lat. 31° 34′ N., and long. 74° 20′ E., and is 702 feet above mean sea-level.

Earth temperature observations were commenced in January 1886, and have been continued to the present time. The hours of observation were originally 4, 10, 16, and 22 hours, but in 1892 the time of the first observation was changed from 4 to 6 hours. The observations included the temperatures (1) on the surface; (2) at a depth of 1 ft.; (3) at a depth of 3 ft.; and (4) at a depth of 6 ft. The thermometer at 6 ft. was only read once a day, viz., at 10 a.m. The thermometers employed have been unchanged throughout.

The thermometer on the surface lies on the top of the ground with a little earth sprinkled about and over the bulb, but not sufficient to interfere with the free access of solar heat or of free radiation at night. The three underground thermometers are firmly attached to stout wooden bars, the bulbs being protected by strong copper shoes which rest on the ground at the bottom of a wooden tube or sheath inserted in the ground to the specified depth.

Table I. gives the mean annual temperatures from 1886 to 1899, as derived from the dry-bulb thermometer in the shed 4 ft. above the ground, at the surface, and at 1 ft., 3 ft., and 6 ft. below the surface.

TABLE I.—MEAN ANNUAL TEMPERATURES.

Thermometers.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
In Shed .	74·1	75·3	75·6	74·5	73·6	73·3	75·4	72·8	74·1	76·3	76·9	75·4	76·1	77·2
Surface .	81·2	80·6	80·5	80·3	79·5	80·3	81·3	79·0	80·3	81·9	81·7	80·2	80·8	80·3
1 Foot .	79·5	78·9	78·9	79·8	78·4	78·3	79·2	77·2	78·1	80·3	80·5	78·7	79·7	79·8
3 Feet .	79·9	79·6	79·8	80·5	79·1	78·9	80·1	78·2	78·9	81·2	81·3	79·8	80·7	80·7
6 Feet .	79·8	80·0	79·9	80·7	79·7	79·1	80·4	78·6	79·2	81·0	81·5	80·3	80·7	80·7

The above data show that the secular changes of temperature as shown by the dry-bulb thermometer in the shed are ordinarily reproduced in the underground records. The maxima in the air temperatures in 1888 and 1892 were reproduced in the surface and in the underground temperatures in the same or following year, and the maxima in 1895 and 1896 were reproduced on the surface in 1895, and at 1 ft., 3 ft., and 6 ft. in 1896. It is, however, noticeable that the minimum of the air temperature in 1886, and the maximum of the air temperature in 1899, are not reproduced in the records of the surface and of the underground temperatures. The minima of 1890-91, 1893, and 1897 in the air temperatures are shown equally well in the records of the surface and underground temperatures. The data thus show that the secular changes of temperature as recorded by the air thermometer are reproduced in the underground temperatures. Down to 3 ft. in depth these changes occur with very little delay, but at a depth of 6 ft. there is a perceptible retardation in the occurrence of a maximum or minimum variation.

TABLE II.—Mean Monthly Temperatures.

Months.	In Shed.	Surface.	1 Foot.	3 Feet.	6 Feet.
	°	°	°	°	°
January	54·0	50·9	57·4	62·8	71·4
February	58·5	57·6	60·2	63·8	69·2
March	70·2	74·3	70·1	69·8	70·5
April	81·4	90·8	82·4	78·9	74·9
May	88·4	101·6	90·0	86·6	81·7
June	94·5	104·6	94·4	91·5	84·9
July	89·8	101·0	94·7	92·8	87·5
August	87·3	99·5	94·0	92·7	88·4
September	84·5	96·3	92·5	92·0	88·9
October	75·0	78·5	82·7	85·6	87·0
November	62·1	61·1	70·8	76·0	82·1
December	54·5	51·6	61·2	67·6	76·2
Annual temperature	75·0	80·7	79·2	80·0	80·2
Annual range	40·5	53·7	37·3	30·0	19·7

The next point to be investigated is the rate at which the annual temperature wave is propagated downwards, and the depth to which this variation extends. It has been shown in previous investigations that the depth to which the annual wave penetrates varies in different regions (1) with the range of temperature, and (2) with the nature of the soil. The present observations show that at Lahore, where the soil is light and alluvial and the range of annual temperature is large, the annual wave is distinctly traceable at the lowest level at which the observations have been recorded. Principal Forbes has shown that at Calton Hill, Edinburgh, the annual temperature wave does not penetrate farther than 40 ft. below the surface, and that below 25 ft. it is very small. At 25 ft. the highest annual temperature occurs about January 4, and the greatest cold about July 13, so that even at this moderate depth the

seasons are reversed. Prof. J. D. Everett has recorded that at Greenwich at a depth of 12·8 ft., the highest annual temperature occurs on September 25, and the lowest on March 27, showing a retardation of about three months in the occurrence of the annual extremes. So far as Lahore is concerned, it is only at a depth of 6 ft. that any retardation is shown, while probably owing to the nature of the soil and to the large annual variation of temperature the amplitude of the annual wave is large at all depths. Table II. shows the annual variations of the temperature (1) in the shed; (2) on the surface; (3) at 1 ft., (4) at 3 ft., and (5) at 6 ft. below the surface.

The above table shows that the maximum positive variation occurs in the shed and on the surface in June, at the depths of 1 ft. and of 3 ft. in July, and at a depth of 6 ft. in September; while the maximum negative variation occurs in the shed, on the surface, and at depths of 1 ft. and of 3 ft. in January, and at a depth of 6 ft. in February.

For five months of the year, viz., in January, February, October, November, and December, the mean temperature at the surface is lower than it is below the surface. In the case of December the differences are as much as 9°·6, 16°·0, and 24°·6 at the respective depths, so that during those five months heat must pass uninterruptedly from the interior to the surface, and thence into space, while during the remaining seven months the heat at the surface is greater than at the lower levels and the flow of heat is reversed.

It is interesting to note, although not connected with the present discussion, that during January and February, and again in November and December, the mean temperature at the surface of the ground is lower than it is at a height of 4 ft. above the surface, and hence that there could be no convective action at work during those months between those levels; while, on the contrary, from March to October the temperature difference between the surface and the shed varies from − 3°·5 to − 13°·2, so that in some months there exists a mean difference of more than 3° per foot within the stratum of the atmosphere lying within 4 ft. of the ground.

The next question is that of the extent and importance of the diurnal temperature wave. Observations for the surface, for 1 ft., and for 3 ft. were recorded at 6-hourly intervals, viz., at 4, 10, 16, and 22 hours. From these observations it will be possible to determine to what depth the diurnal wave penetrates. Table III. gives this information.

The above shows that the daily temperature wave is just observable at a depth of 1 ft., but is practically evanescent at a depth of 3 ft. Taking the mean monthly values of January and June as examples, the records show that in January between 4 and 10 hours the surface temperature rises 17°; during the next 6 hours it rises 8°·7 to its diurnal maximum (64°·5) at 16 hours, after which hour it falls 20°·3 to 22 hours, and thereafter 5°·4 to the minimum (38°·8) at 4 hours. There is thus a mean daily range of 25°·7 on the surface in January. At a depth of 1 ft. the temperature falls 0°·1 between 4 and 10 hours, and is at its diurnal minimum (56°·8) at that hour; it then increases 1°·0 between 10 and 16 hours, and another 0°·3 between 16 and 22 hours, when the diurnal maximum (58°·1) is reached. There is then a fall of 1°·2 to the 4 hours' reading. The mean daily range is 1°·2.

The differences introduced by the descent of 1 ft. are consequently as follows:—The mean daily range is reduced from 25°·7 to 1°·2, and the occurrence of the diurnal extremes is retarded 6 hours. At 3 ft. the mean diurnal maximum is at 10 hours (62°·9), and the minimum (62°·7) is recorded at 16 and 22 hours. The mean daily range is thus 0°·2.

TABLE III.—Mean Temperatures at 6-Hourly Intervals.

Months.	Thermometers.	4 Hrs.	10 Hrs.	16 Hrs.	22 Hrs.	Daily Range.
		°	°	°	°	°
January.	Surface	38·8	55·8	64·5	44·2	25·7
	1 foot	56·9	56·8	57·8	58·1	1·2
	3 feet	62·8	62·9	62·7	62·7	0·2
February	Surface	43·0	62·7	74·5	50·0	29·5
	1 foot	59·8	59·7	60·3	61·1	1·4
	3 feet	63·8	63·9	63·8	63·8	0·1
March	Surface	53·2	86·6	96·2	61·2	43·0
	1 foot	69·9	69·7	69·9	71·1	1·4
	3 feet	69·6	69·8	69·8	69·8	0·2
April	Surface	63·3	109·6	117·5	72·8	54·2
	1 foot	82·0	81·4	83·5	82·6	2·1
	3 feet	78·8	79·0	79·0	78·9	0·2
May	Surface	73·4	121·7	128·6	82·5	55·2
	1 foot	89·0	89·1	89·0	90·8	1·8
	3 feet	86·5	86·7	86·7	86·7	0·2
June	Surface	80·8	120·3	128·6	88·5	47·8
	1 foot	94·2	94·2	94·1	94·9	0·8
	3 feet	91·4	91·5	91·5	91·5	0·1
July	Surface	82·9	111·7	121·2	88·3	38·3
	1 foot	94·6	94·4	94·5	95·3	0·9
	3 feet	92·8	92·9	92·8	92·8	0·1
August	Surface	80·7	112·6	118·9	85·7	38·2
	1 foot	93·9	93·7	93·8	94·7	1·0
	3 feet	92·7	92·7	92·7	92·7	0·0
September	Surface	73·4	114·4	117·6	79·8	44·2
	1 foot	92·0	92·1	92·4	93·3	1·3
	3 feet	92·0	92·1	92·0	91·9	0·2
October	Surface	56·0	98·6	96·1	63·4	42·6
	1 foot	81·8	82·3	83·1	83·5	1·7
	3 feet	85·6	85·7	85·5	85·4	0·3
November	Surface	44·4	71·0	77·8	51·2	33·4
	1 foot	69·9	70·2	71·4	71·4	1·5
	3 feet	76·1	76·1	75·9	75·9	0·2
December	Surface	37·9	59·9	65·3	43·4	27·4
	1 foot	60·4	60·6	61·9	61·8	1·5
	3 feet	67·7	67·7	67·5	67·5	0·2

Turning next to June, when the amplitude of the daily oscillation is much greater than in January, the observations show that the temperature between 4 and 10 hours on the surface rises 39°·5; during the next 6 hours it rises 8°·3 to its diurnal maximum (128°·6) at 16 hours, after which it falls 40°·1 to 22 hours, and 7°·7 to the minimum (80°·8) at 4 hours. There is thus a mean daily range of 47°·8, while the diurnal extremes are at 4 and 16 hours. At a depth of 1 ft. the temperature is steady between 4 and 10 hours, falls 0°·1 between 10 and 16 hours, when it is at its diurnal minimum (94°·1), then rises 0°·8 between 16 and 22 hours, when it reaches its diurnal maximum (94°·9), and thereafter falls 0°·7 to 4 hours. Thus the differences introduced by the descent of 1 ft. are as follows:—The mean daily range of temperature

is reduced from 47°·8 to 0°·8, and the extremes of temperature are recorded at 16 and 22 hours. At 3 ft. the mean diurnal range is reduced to 0°·1, and there is practically no diurnal variation. This is noticeable, as the amplitude of the diurnal oscillation on the surface in January is only 25°·7, while in June it is as much as 47°·8.

On the mean of the whole year the following figures represent the daily range of temperature at the different depths :—

Thermometers.	4 hrs.	10 hrs.	16 hrs.	22 hrs.	Daily Range.
	°	°	°	°	°
Surface . . .	60·6	93·7	100·6	67·6	40·0
1 foot . . .	78·7	78·7	79·3	79·9	1·2
3 feet . . .	80·0	80·1	80·0	80·0	0·1

On the surface the mean maximum occurs at 16 hours, at a depth of 1 ft. at 22 hours, and at a depth of 3 ft. at 10 hours, so that there occurs a retardation of 6 hours for each foot of descent. The minimum is at 4 hours on the surface, and between 4 and 10 hours at a depth of 1 ft.

From the preceding discussion it would appear that the secular changes of temperature, which are shown in the observations of a long series of years, as also the large annual oscillation due to the heat of summer and the cold of winter, are observable at the depths of 1 ft., 3 ft., and 6 ft. below the surface, but that the briefer oscillation due to the heat of the day and the cold of the night is only just perceptible at 1 ft., and is practically not perceptible at 3 ft.

Two other points may be mentioned here. From Table I. it will be seen that 1899, which was a year of very deficient rainfall, was that in which the air temperature was at its maximum for the whole series, but that the underground temperatures for that year were in no way remarkable; and, second, that in 1896, which was the year of maximum surface and underground temperature, the air temperature was higher than in any other year except the aforesaid 1899. This leads to the further inquiry, viz. whether the underground temperature has any effect on the surface or air temperature, or whether the variations in these elements are wholly dependent on variations in the solar heat. From Table I. the following figures are obtained, showing the mean temperature of the air, of the surface, and at the depths of 1 ft., 3 ft., and 6 ft. for the whole period 1886 to 1899 :—

Thermometers.	Shed.	Surface.	1 foot.	3 feet.	6 feet.
	°	°	°	°	°
Mean Temperature, 1886-1899 .	75·0	80·7	79·2	80·0	80·2
Amplitude of Oscillation . .	4·4	2·9	3·3	3·1	2·9

These figures show that there exist two independent sources of heat, the one fundamental proper to the terrestrial globe, the other due to the effect of the sun.

The heat which is acquired by the earth from the sun is exactly

balanced by that which escapes from the earth from all points of the surface, but it has been shown that this heat affects the underground temperature to the lowest depth at which temperatures have been recorded at Lahore, though these changes become less and less sensible as the measuring-point recedes from the surface. Hence before attempting to ascertain whether there be any appreciable variation in the emission of heat from the fundamental source, it becomes necessary to eliminate the variations due to the action of the sun. The above figures show that there is a flow of heat from the fundamental source, *i.e.* from the interior towards the surface—slight between 6 ft. and 3 ft., and brisk between 3 ft. and 1 ft. Above 1 ft. the flow of heat towards the surface disappears in the more massive downflow from the surface to the interior, due to the heating effect of the sun. There is, however, no reason to suppose that the reverse flow, though untraceable, is extinguished, and what is required is to ascertain whether there are variations in the flow of heat from the fundamental source. The temperature at great depths is supposed to be sensibly fixed at a given place, but it is possible there may be slight periodic changes which may influence the weather, though they have no sensible influence on the mean temperature of the climates. Accepting the readings of the dry-bulb thermometer in the shed as indicative of the variations due to changes in the sun, it will be seen that for the whole period from 1886 to 1899 there is a mean difference of 5°·2 between the air temperature and the underground temperature at a depth of 6 ft. Adding 5°·2 to the mean annual dry-bulb temperature, calculated values are obtained showing what, according to this argument, should be the annual mean temperature at 6 ft., allowing for variations in the external source of heat. Comparing these calculated values with the actual recorded values, a difference is obtained which may exhibit the fluctuations taking place in the internal source. Table IV. shows these variations.

TABLE IV.—Observed and Calculated Temperatures.

Years.	In Shed.	Calculated.	Actual.	Difference.
	°	°	°	°
1886	74·1	79·3	79·8	+0·5
1887	75·3	80·5	80·0	−0·5
1888	75·6	80·8	79·9	−0·9
1889	74·5	79·7	80·7	+1·0
1890	73·6	78·8	79·7	+0·9
1891	73·3	78·5	79·1	+0·6
1892	75·4	80·6	80·4	−0·2
1893	72·8	78·0	78·6	+0·6
1894	74·1	79·3	79·2	−0·1
1895	76·3	81·5	81·0	−0·5
1896	76·9	82·1	81·5	−0·6
1897	75·4	80·6	80·3	−0·3
1898	76·1	81·3	80·7	−0·6
1899	77·2	82·4	80·7	−1·7

The variations are all small, with the exception of 1899, when the air temperature was very high.

The above data show an oscillation between 1886 and 1889, a second oscillation between 1889 and 1893, and, finally, a decrease from 1893 to 1899, broken by a brief rise in 1897.

Jaipur.

This observatory was founded in 1880, and stands in a large garden surrounded by a rectangular wall with small towers at the corners; outside the wall, and about thirty yards distant, are the earth temperature thermometers. The station of Jaipur stands on a plateau of eastern Rajputana at the west foot of one of the ranges of low hills that form part of the Araveli system. The soil is generally sandy. The Observatory is situated in lat. 26° 55′ N. and long. 75° 50′ E., and is 1431 ft. above mean sea-level.

Earth temperature observations were commenced in 1884, and have continued up to the present time. The hours of observation were 4, 10, 16, and 22 hours, and the observations included the temperatures (1) on the surface, (2) at a depth of 4 ins., (3) at a depth of 1 ft., (4) at a depth of 3 ft., (5) at a depth of 10 ft., (6) at a depth of 20 ft., and (7) at a depth of 45·6 ft. The thermometers at 10 ft., 20 ft., and 45·6 ft. below the surface were only read once daily, viz. at 10 a.m.

The thermometer employed at 4 ins. appears to have gone out of order in November 1896. The following gives the 4-year period annual mean temperatures for this element :—

1882–84	81°·3
1885–88	81·4
1889–92	81·3
1893–96	80·3
1897–00	76·6

The above data confirm the view that from about November 1896 the thermometer at 4 ins. depth has been out of order, and the readings of this thermometer for this period have consequently been rejected.

TABLE V.—Mean Temperatures at 10 A.M.

Years.	In Shed.	On Surface.	4 Inches.	1 Foot.	3 Feet.	10 Feet.	20 Feet.	45·6 Feet.
	°	°	°	°	°	°	°	°
1884	81·3	98·1	79·9	77·4	79·0	79·5	80·2	...
1885	80·6	101·1	78·1	77·1	79·0	79·0	79·4	...
1886	81·6	103·0	77·5	78·0	80·0	80·2	79·7	...
1887	81·8	99·2	79·3	76·3	79·3	80·0	80·3	...
1888	78·3	102·2	77·9	75·9	79·8	80·4	80·4	81·0
1889	78·5	103·9	78·2	77·1	80·7	80·9	80·6	81·3
1890	80·2	105·5	78·7	77·7	80·9	81·2	81·0	81·4
1891	81·5	104·8	77·6	76·9	80·4	80·7	80·8	81·6
1892	82·8	105·2	77·6	77·2	80·5	80·8	81·2	81·7
1893	79·5	104·6	77·8	74·9	78·8	80·0	80·5	81·8
1894	80·6	104·2	79·2	76·2	79·8	81·2	80·5	81·7
1895	82·5	107·7?	77·0	77·6	81·3	81·4	80·6	81·6
1896	83·3	107·9?	75·0?	78·6	82·4	82·6	81·7	81·8
1897	82·9	108·3?	73·2?	77·9	81·6	82·6	81·4	82·0
1898	83·3	116·2?	72·5?	78·1	82·4	82·2	82·0	82·0
1899	84·1	114·5?	71·5?	79·3	83·0	83·3	82·3	82·1
Means	81·4	105·4	76·9 or 78·2	77·3	80·6	81·0	80·8	81·7
Amplitudes of Oscillation	5·8	18·1	8·4 or 2·4	4·4	4·2	4·3	2·9	1·1

As mentioned above, it is obvious that the recorded temperatures at 4 ins. below the surface from 1896 onward are erroneous, and it appears equally unquestionable that the surface temperatures are also incorrect from about the year 1895, while the mean temperature of the 10 ft. thermometer is somewhat doubtful.

The preceding data show, as was the case with the Lahore observations, that the changes of temperature as recorded by the dry-bulb thermometer in the shed are reproduced in the underground temperatures and in the same year. The maximum dry-bulb temperature was reported in 1899 (84°·1), and the highest temperatures in the whole series at depths of 1 ft., 3 ft., 10 ft., 20 ft., and 45½ ft. were registered in the same year similarly with the minimum in 1893 in the air temperature. This minimum was reproduced at 1 ft., 3 ft., 10 ft. and 20 ft., though it was not noticeable at 45½ ft. Hence it follows that variations in the air temperature brought about by secular changes of temperature are reproduced in all the underground temperatures approximately at the same time. It is also worthy of note that at depths of 1 ft., 3 ft., and 10 ft. the amplitude of the temperature oscillation is on the mean of the whole series approximately alike at all depths, though at 20 ft. and 45½ ft. the extent of the oscillation sensibly diminishes.

Passing on to the question of the seasonal variations, Table VI. gives the mean monthly temperatures in the shed, on the surface, and at the different depths underground—

TABLE VI.—Mean Monthly Temperatures.

Months.	In Shed.	Surface.	4 Ins.	1 Foot.	3 Feet.	10 Feet.	20 Feet.	45½ Feet
	°	°	°	°	°	°	°	°
January . . .	58·6	63·6	59·8	61·5	66·7	74·9	80·3	81·6
February . .	62·9	70·3	67·4	66·8	68·1	72·9	79·4	81·7
March . . .	74·8	83·4	78·8	77·4	74·4	74·0	78·4	81·7
April . . .	84·6	95·2	89·7	87·6	81·9	77·7	78·1	81·8
May . . .	90·2	102·1	96·2	94·8	87·8	82·5	78·8	81·7
June . . .	90·7	100·3	95·2	95·2	91·0	85·3	80·0	81·6
July . . .	83·8	92·0	87·9	89·0	88·6	86·0	81·3	81·6
August . . .	81·4	89·5	85·4	86·4	86·4	86·1	82·2	81·5
September . .	82·0	91·8	87·7	87·7	87·1	85·9	82·8	81·5
October . . .	75·9	85·5	83·5	83·2	85·0	85·5	83·0	81·5
November . .	67·4	72·9	71·4	73·0	78·2	82·6	83·0	81·6
December . .	59·9	64·5	61·0	63·3	70·9	78·3	82·3	81·6
Annual Temperature	76·0	84·3	80·3	80·5	80·5	81·0	80·8	81·6
Annual Range .	32·1	38·5	36·4	33·7	24·3	13·2	4·9	0·3

The maximum positive variation occurs in June in the shed, but in May on the surface and at a depth of 4 ins.; it again occurs in June at depths of 1 ft. and of 3 ft.; in August at a depth of 10 ft.; in October and November at a depth of 20 ft., and in April at a depth of 45½ ft.; while the maximum negative variation occurs in January in the shed, on the surface, and at the depths of 4 ins., 1 ft., and 3 ft.; in February at a depth of 10 ft.; in April at a depth of 20 ft.; and in August to October at a depth of 45½ ft.

The amplitude of the annual oscillation is greatest on the surface, and thence diminishes steadily downward, and at 45½ ft. amounts to only 0°·3. Hence at about this depth below the surface under the conditions present at Jaipur the temperature oscillation due to the heat of summer and the cold of winter practically disappears. This result agrees with that determined by Prof. Forbes at Calton Hill, Edinburgh. Table VII. gives comparative data of Lahore and Jaipur.

TABLE VII.—Temperature Results at Lahore and Jaipur.

Stations.		In Shed.	Surface.	4 Ins.	1 Foot.	3 Feet.	6 Feet.	10 Feet.	20 Feet.	45½ Feet.
		°	°	°	°	°	°	°	°	°
Lahore .	Annual Mean Temperature.	75·0	80·7	...	79·2	80·0	80·2	...	...	...
Jaipur .		76·0	84·3	80·3	80·5	80·5	...	81·0	80·8	81·6
Lahore .	Annual Range.	40·5	53·7	...	37·3	30·0	19·7	...	...	...
Jaipur .		32·1	38·5	36·4	33·7	24·3	...	13·2	4·9	0·3

The mean annual air temperatures at Lahore and Jaipur are nearly alike, but the surface and underground temperatures are higher at Jaipur than they are at the more northern station. The annual range of temperature in the shed, on the surface, and underground are all greater at Lahore than at Jaipur.

For the determination of the extent and importance of the diurnal temperature wave the information available is the same as that available for Lahore with the addition of the observations at 4 ins. below the surface. Table VIII. gives this information.

The above data show considerable differences when compared with similar information for Lahore. The diurnal range is much larger at Jaipur than at Lahore, though in the case of the annual range of temperature the reverse was the case. In both places the diurnal oscillation has practically disappeared at a depth of 3 ft. It is remarkable that in the case of the surface temperature the maximum in the months of April, May, September, October, November, and December, was recorded at 10 hours instead of at 16 hours. At all depths below the surface the maximum was nearly always recorded at 16 hours, and the minimum at 4 hours.

On the mean of the whole year the following figures represent the daily range of temperature on the surface and at the different depths :—

Thermometers.	4 hrs.	10 hrs.	16 hrs.	22 hrs.	Daily Range.
	°	°	°	°	°
Surface . . .	60·5	105·4	105·1	66·2	44·9
4 inches . . .	72·4	76·9	92·5	79·7	20·1
1 foot . . .	77·8	77·3	84·7	82·3	7·4
3 feet . . .	80·4	80·6	80·6	80·5	0·2

The daily maximum is reported at 10 hours on the surface, and at 16 hours at all depths below the surface; the daily minimum is recorded at 4 hours on the surface and at all depths except 1 ft., when it is

delayed till 10 hours. Comparing the above figures with those at Lahore it will be observed that at a depth of 3 ft. the mean temperature is about 0°·5 higher at Jaipur than it is at Lahore; at a depth of 1 ft. the mean

TABLE VIII.—Mean Temperatures at 6 Hourly Intervals.

Months.	Thermometers.	4 Hours.	10 Hours.	16 Hours.	22 Hours.	Daily Range.
		°	°	°	°	°
January	Surface	42·0	81·1	84·4	47·2	42·4
	4 inches	53·0	56·6	70·7	59·8	17·7
	1 foot	59·3	58·1	65·5	63·4	7·4
	3 feet	66·6	66·7	66·9	66·7	0·3
February	Surface	45·0	89·7	95·2	51·1	50·2
	4 inches	58·8	62·2	81·6	67·7	22·8
	1 foot	64·2	62·8	71·3	69·3	7·1
	3 feet	67·9	68·1	68·2	68·1	0·3
March	Surface	54·7	107·0	110·3	61·6	55·6
	4 inches	69·2	73·8	93·7	78·6	24·5
	1 foot	74·4	73·4	81·8	80·0	8·4
	3 feet	74·2	74·4	74·5	74·4	0·3
April	Surface	63·8	123·0	122·2	71·8	59·2
	4 inches	79·3	84·8	105·1	89·8	25·8
	1 foot	84·7	83·9	91·9	90·2	8·0
	3 feet	81·7	81·9	82·0	82·0	0·3
May	Surface	72·9	127·2	126·3	81·1	54·3
	4 inches	86·8	91·5	110·3	96·5	23·5
	1 foot	92·0	91·2	98·7	97·0	7·5
	3 feet	87·6	87·8	87·9	87·8	0·3
June	Surface	78·4	118·5	120·3	84·3	41·9
	4 inches	87·9	91·7	106·2	95·1	18·3
	1 foot	92·2	92·1	99·0	97·1	6·9
	3 feet	91·0	91·1	91·2	91·1	0·2
July	Surface	76·9	104·7	106·2	80·6	29·3
	4 inches	82·6	86·0	95·9	87·2	13·3
	1 foot	86·5	86·6	92·5	90·1	6·0
	3 feet	88·6	88·8	88·7	88·6	0·2
August	Surface	75·0	101·3	103·3	78·5	28·3
	4 inches	80·1	83·7	93·5	84·5	13·4
	1 foot	84·0	84·0	90·1	87·5	7·1
	3 feet	86·2	86·4	86·4	86·3	0·2
September	Surface	70·1	111·6	110·3	75·3	41·5
	4 inches	80·2	85·1	98·9	86·5	18·7
	1 foot	84·7	84·7	92·0	89·1	7·3
	3 feet	86·9	87·1	87·2	87·0	0·3
October	Surface	58·4	114·1	106·6	63·7	55·7
	4 inches	74·0	80·4	97·9	81·9	23·9
	1 foot	79·9	79·9	88·3	84·7	8·4
	3 feet	84·9	85·1	85·2	84·9	0·3
November	Surface	47·3	99·9	91·8	52·7	52·6
	4 inches	63·1	68·6	84·5	69·8	21·4
	1 foot	70·1	69·8	77·6	74·4	7·8
	3 feet	78·1	78·3	78·4	78·1	0·3
December	Surface	41·2	86·6	83·9	46·3	45·4
	4 inches	53·9	58·1	71·3	59·9	17·4
	1 foot	61·0	60·5	67·6	64·5	7·1
	3 feet	70·7	70·9	71·0	70·8	0·3

temperature is lower at 4 and 10 hours, and higher at 16 and 22 hours at Jaipur than it is at Lahore. The mean daily range also shows considerable divergencies—more particularly the large daily range at 1 ft. at Jaipur, compared with that at Lahore.

The following figures show the mean temperature of the air, of the surface, and of the different depths below the surface for Jaipur for the period 1884-1899 :—

In Shed.	Surface.	4 inches.	1 foot.	3 feet.	10 feet.	20 feet.	45½ feet.
76°·0	84°·3	80°·3	80°·5	80°·6	81°·0*	80°·8	81°·7

* Doubtful.

The preceding tables exhibit the same characteristics as those shown by the Lahore data, viz., a flow of heat from the interior towards the surface and a flow from the surface to a short distance underground. The spot with the lowest temperature lies at 4 ins. below the surface, and from this point temperature increases downward, the increase being slight between 4 ins. and 20 ft., and rapid between 20 ft. and 45½ ft. In connection with this downward distribution of temperature it must be remembered that the records of 4 ins. are certainly erroneous. Following the practice adopted in discussing the Lahore observations, the following table has been constructed, showing the calculated and the observed temperature readings at 45½ ft. These readings are only available from 1888, as observations at this depth were not recorded before that year Table IX. shows the differences between the calculated and observed readings at 45½ ft., the mean difference between the air temperature and the 45½ ft. temperature having been 5°·7.

TABLE IX.—Observed and Calculated Temperatures.

Years.	In Shed.	Calculated.	Actual.	Difference.
	°·	°·	°·	°·
1888	75·0	80·7	81·0	+0·3
1889	76·6	82·3	81·3	−1·0
1890	76·8	82·5	81·4	−1·1
1891	76·3	82·0	81·6	−0·4
1892	77·4	83·1	81·7	−1·4
1893	74·5	80·2	81·8	+1·6
1894	76·1	81·8	81·7	−0·1
1895	77·1	82·8	81·6	−1·2
1896	78·3	84·0	81·8	−2·2
1897	77·3	83·0	82·0	−1·0
1898	78·1	83·8	82·0	−1·8
1899	78·9	84·6	82·1	−2·5

The above data show that the variations between the actual and calculated temperatures at a depth of 45½ ft. at Jaipur are considerably larger than the variations between the actual and calculated temperatures at a depth of 6 ft. at Lahore, but the oscillations disclosed are fairly similar in both series. Thus there are maxima in 1893 and 1897, and minima in 1892, in 1896, and in 1899. There is a fall from 1893 to 1899 broken by a brief rise in 1897. The maximum positive difference of the series was recorded in 1889 in Lahore, and in 1893 in Jaipur, and the maximum negative difference of the series in 1899 at both stations.

Dehra Dun.

The Observatory of Dehra Dun is situated in the eastern Dun, a mountain valley at the foot of the Kumaun Himalayas. It is closed in to the north by the main range of the Himalayas, and to the south by the Siwalek Hills, a mass of Himalayan débris which shuts off the district from the wide Gangetic plain. Dehra Dun lies in lat. 30° 19′ N., and long. 78° 5′ E., and the Observatory is 2233 ft. above mean sea-level.

Earth temperature observations were commenced at this station in January 1884, and have been continued to the present time. Only one observation per diem is made at this station, viz. at 3 p.m., and there is no surface thermometer. The observations were made at depths below the surface of 1·1 ft., 3·2 ft., 6·4 ft., 12·8 ft., and 25·6 ft., so that they are not directly comparable with either the Lahore or Jaipur observations.

Table X. gives the mean annual temperatures from 1884 to 1899 as derived from the dry-bulb temperature in the shed 4 ft. above the ground, and from the underground temperatures at 1·1 ft., at 3·2 ft., at 6·4 ft., at 12·8 ft., and at 25·6 ft., all recorded at 3 p.m.

TABLE X.—MEAN ANNUAL TEMPERATURES AT 3 P.M.

Years.	In Shed.	1·1 Foot.	3·2 Feet.	6·4 Feet.	12·8 Feet.	25·6 Feet.
	°	°	°	°	°	°
1884	78·0	74·5	74·2	74·6	74·9	75·3
1885	76·8	73·5	73·4	74·2	74·8	?
1886	77·9	73·7	73·6	74·2	?	?
1887	78·1	73·9	?	74·6	?	?
1888	78·3	73·6	74·8	75·1	75·7	75·4
1889	78·6	73·9	75·2	75·5	76·2	76·0
1890	78·9	74·7	75·6	76·2	76·8	76·3
1891	78·3	72·6	73·8	74·4	75·1	75·3
1892	81·0	74·9	76·0	76·1	76·3	75·8
1893	75·3	71·8	72·9	73·9	75·3	75·6
1894	76·7	73·4	74·3	74·9	75·5	75·5
1895	78·7	74·2	74·5	74·8	75·2	75·2
1896	80·6	75·8	76·0	76·1	76·3	75·8
1897	79·6	75·2	75·6	75·7	76·1	76·1
1898	79·0	74·6	75·4	75·6	76·4	76·6
1899	80·1	75·4	75·9	75·7	75·9	75·9
Mean	78·5	74·1	74·7	75·1	75·8	75·8
Amplitude of Oscillation	5·7	4·0	3·1	2·3	2·0	1·4

The above data show that the secular changes of temperature as indicated by the dry-bulb thermometer in the shed are reproduced in the underground temperature records, and generally in the same year. Thus the maximum of the whole series in the dry-bulb temperature was in 1892, and in that year there are shown, at all the different depths, high temperature readings, though not necessarily the maxima of the series. Similarly, the absolute minimum of the dry-bulb temperatures of the series[1] was in 1891, and though the absolute minima of the underground temperatures were not recorded in this year, yet the underground tem-

[1] The years 1884 to 1888 are omitted, as these shed temperatures were recorded at another spot.

perature records disclosed a marked depression of temperature at this time at all depths.

Table XI. gives the mean monthly temperatures in the shed and at the different depths underground.

TABLE XI.—Mean Monthly Temperatures.

Depth.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Annual Range.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Air . .	63·6	66·4	78·1	88·9	93·3	89·9	82·3	80·4	82·0	78·8	72·3	66·2	78·5	29·7
1·1 ft. .	57·2	58·8	67·6	78·8	86·4	87·8	84·1	82·2	81·4	76·3	68·1	60·3	74·3	30·6
3·2 ft. .	62·1	51·1	66·9	75·8	82·5	84·9	83·4	82·0	81·7	78·3	72·1	66·4	74·8	23·8
6·4 ft. .	67·6	55·7	67·2	71·7	77·0	80·5	81·6	81·6	81·3	79·8	76·1	71·6	75·1	15·9
12·8 ft. .	74·1	72·1	71·0	71·4	73·2	75·3	77·4	79·3	79·8	79·5	78·4	76·5	75·7	8·8
25·6 ft. .	76·4	75·7	75·1	74·5	74·2	74·2	74·5	76·1	76·9	77·0	77·1	76·8	75·7	2·9

The maximum positive variation in the annual oscillation occurs in May in the shed, in June at the depths of 1·1 ft. and 3·2 ft., in July and August at the depth of 6·4 ft., in September at a depth of 12·8 ft., and in November at a depth of 25·6 ft. The maximum negative variation of the annual oscillation occurs in January in the shed and at a depth of 1·1 ft., in February at the depths of 3·2 ft. and 6·4 ft., in March at the depth of 12·8 ft., and in May and June at the depth of 25·6 ft. There is such a retardation in the occurrence of the maximum of six months, and in the case of the minimum of five months. The amplitude of the annual oscillation is greatest (30°·6) at the depth of 1·1 ft., and is least (2°·9) at a depth of 25·6 ft.

Following the method adopted in discussing the lowest level underground temperatures at Lahore and Jaipur, Table XII. has been constructed showing the calculated and observed temperatures, and the differences between these readings. The mean difference between the temperature in the shed and at a depth of 25·6 ft. being 2°·7, the following are the results :—

TABLE XII.—Observed and Calculated Temperatures.

Years.	In Shed.	Calculated.	Actual.	Difference.
	°	°	°	°
1888	78·3	75·6	75·4	−0·2
1889	78·6	75·9	76·0	+0·1
1890	78·9	76·2	76·3	+0·1
1891	78·3	75·6	75·3	−0·3
1892	81·0	78·3	75·8	−2·5
1893	75·3	72·6	75·6	+3·0
1894	76·7	74·0	75·5	+1·5
1895	78·7	76·0	75·2	−0·8
1896	80·6	77·9	75·8	−2·1
1897	79·6	76·9	76·1	−0·8
1898	79·0	76·3	76·6	+0·3
1899	80·1	77·4	75·9	−1·5

These figures agree in their main characteristics with the Lahore and Jaipur figures of similar data. The oscillations disclosed are the same in all three cases. Thus there are maxima in 1889, 1893, and 1898; and

minima in 1892, 1896, and 1899. The maximum positive difference of the series was recorded in 1893, and the maximum negative difference in 1896, so that in this respect there was some dissimilarity between the records.

Table XIII. gives comparative data for the three stations of Lahore, Jaipur, and Dehra Dun.

TABLE XIII.—Temperature Results at Lahore, Jaipur, and Dehra Dun.

Stations.		Shed.	Surface.	4 ins.	1 ft. and 1·1 ft.	3 ft. and 3·2 ft.	6 ft. and 6·4 ft.	10 ft.	12·8 ft.	20 ft.	25·6 ft.	45·6 ft.
		°	°	°	°	°	°	°	°	°	°	°
Lahore	Annual Mean Temperature	75·0	80·7	79·1	79·2	80·0	80·2	80·5	80·7	80·8	81·0	81·7
Jaipur		76·0	84·3	80·3	80·5	80·5	80·7	81·0	81·1	81·3	81·4	81·6
Dehra Dun		78·5	85·5	82·7	74·3?	74·8	75·1	75·5	75·7	75·7	75·7	76·3
Lahore	Annual Range	40·5	53·7	...	37·3	30·0	19·7	...	...	...	...	...
Jaipur		32·1	38·5	36·4	33·7	24·3	...	13·2	...	4·9	...	0·3
Dehra Dun		29·7	...	...	30·6	23·8	15·9	...	8·8	...	2·9	...

The above data give fairly consistent results. They all show that the coolest spot in the earth's crust is between the surface and a depth of 1 foot, and that below that depth the heat increases. The rate of increase is irregular, and owing to the faulty observations in some cases, is not altogether reliable, but all the observations are consistent in showing a diminution in the rate of increase as the depth increases. If values be interpolated for those depths in the records of the different stations for which actual observations are not available, the curve on Fig. 1 is obtained which probably exhibits fairly correctly the curve of temperature between the surface and 45½ feet below the surface in Upper India.

The curve on Fig. 1 is not quite regular, because the descent increments are not regular, but if we take a form in which each of the divisions represents 1 ft. of descent, the curve in Fig. 2 is obtained.

The preceding data show that there is a regular rise amounting to a little over 1° between 1 ft. and 13 ft., but that thereafter the rate of increment decreases and amounts to only 0°·7 for the next 32 ft. of descent. The ordinarily accepted rate of increase for descent after passing through the thin stratum in which variations of temperature due to conduction inward of summer heat and winter cold are perceptible, is about 1° C. per 30 metres of descent, or about 1° F. per 50 ft. The result obtained from the Indian figures is 0°·7 in 32 ft. or 1°·1 in 50 ft.

If it be admitted that the secular and seasonal variations of temperature penetrate to the lowest depth to which the observations of underground temperature have been pushed, and granting that, after passing downward from the surface through this stratum, which is, on the average, only about 30 metres thick, we reach strata at which the temperature of any spot is sensibly fixed, then it follows that the records of underground temperatures at the above depths should show the same, though probably retarded, oscillations, as the air thermometer and any variations in the underground temperatures should be directly referable to the variations in the external source of heat, viz. the sun. The preceding tables do not show this to be the case. The maximum underground temperatures of the series of years 1884-99 do not occur coin-

cidently with the maximum of the air thermometer, and the minimum underground temperatures of the series of years cannot be connected with the minimum of the air thermometer. Instead of this there would

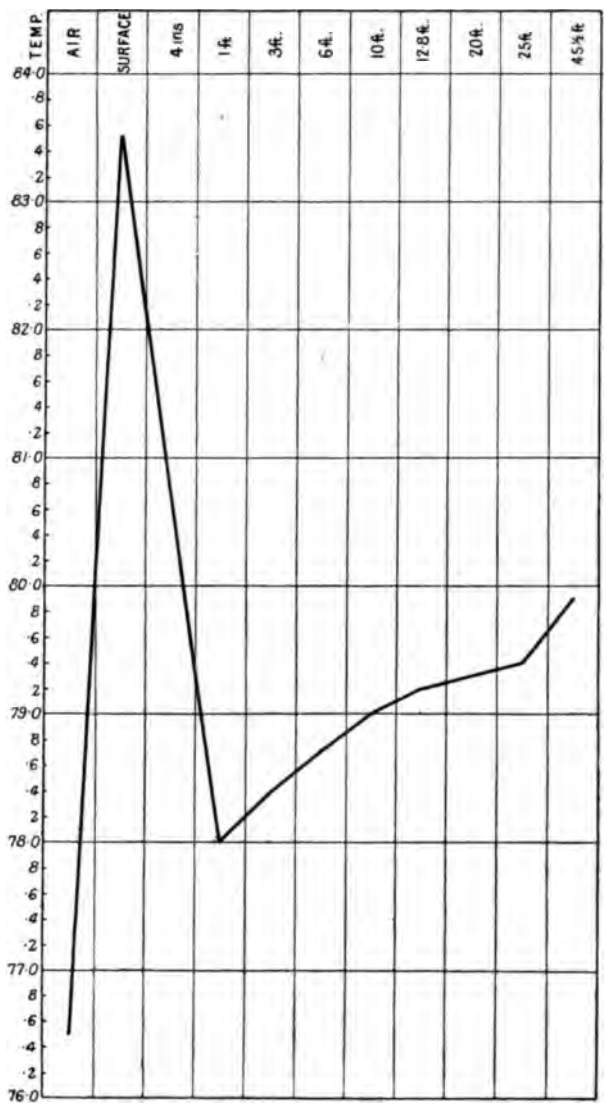


FIG. 1.

appear to be changes in the underground thermometers which are unconnected with the changes of the air thermometer, and in order to determine if possible the extent and order of these changes, due perhaps to changes in the fundamental source of heat, the rough and ready method was adopted which is described above.

This method consists in ascertaining the mean difference between the average temperature in the air and the average temperature at the lowest depth at which observations have been recorded under ground. By applying this difference to the mean air temperature of each individual year, we ascertain what should be the temperature at the given depth, allowing for changes in the intensity of the external source

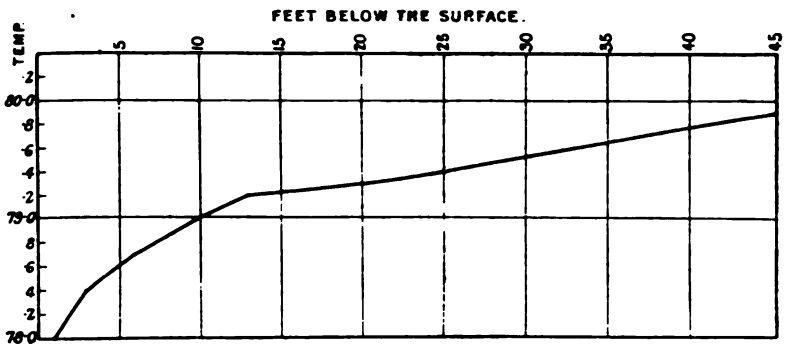


FIG. 2.

of heat, and presuming that there are no variations in the fundamental source. As a matter of fact, it is found that these calculated values do not agree with the actual recorded values. There are slight differences between the two which, as variations in the solar heat have been allowed for by taking the mean air temperature of each year, may presumably be due to variations in the fundamental source of heat, or in other words, to variations in the heat proper to the terrestrial globe. These variations for the three stations under discussion are as follows :—

TABLE XIV.—ANNUAL DIFFERENCES BETWEEN THE CALCULATED AND ACTUAL TEMPERATURES AT THE LOWEST LEVEL OBSERVING POINT.

Years.	Lahore.	Jaipur.	Dehra Dun.	Mean of all Three Stations.
	°	°	°	°
1886	+0·5	?	?	+0·5
1887	−0·5	?	?	−0·5
1888	−0·9	+0·3	−0·2	−0·3
1889	+1·0	−1·0	+0·1	0
1890	+0·9	−1·1	+0·1	0
1891	+0·6	−0·4	−0·3	0
1892	−0·2	−1·4	−2·5	−1·4
1893	+0·6	+1·6	+3·0	+1·7
1894	−0·1	−0·1	+1·5	+0·5
1895	−0·5	−1·2	−0·8	−0·8
1896	−0·6	−2·2	−2·1	−1·6
1897	−0·3	−1·0	−0·8	−0·7
1898	−0·6	−1·8	+0·3	−0·7
1899	−1·7	−2·5	−1·5	−1·9

Charting the variations given in the final column of Table XIV., and comparing them with the annual variations of rainfall over India, the curves in Fig. 3 are obtained.

The likeness between these two curves is unmistakable, and the conclusion is that the variations between the calculated and actual temperatures at the lowest depths are functions of the rainfall variations,

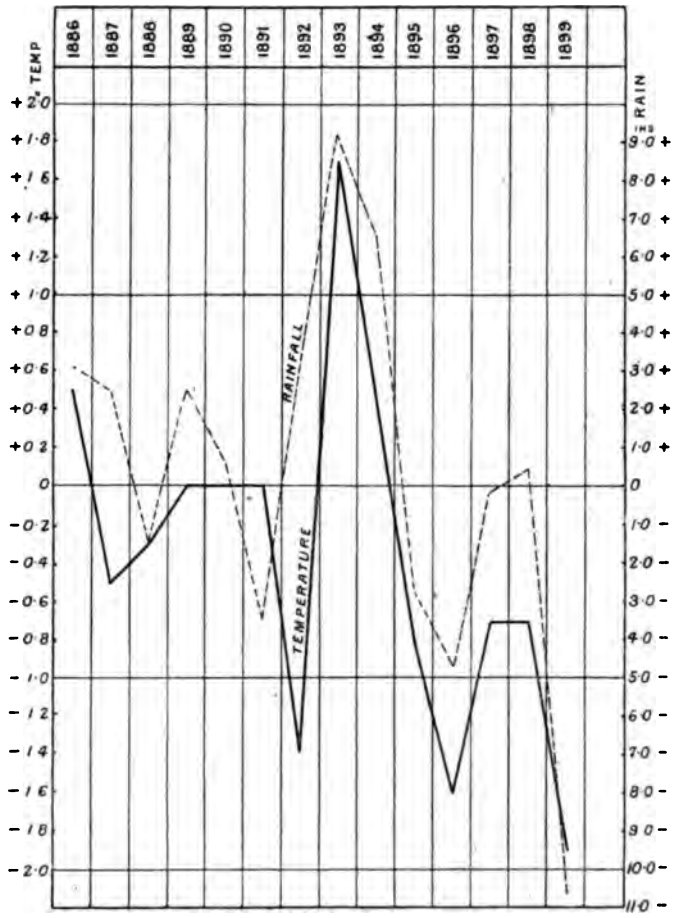


FIG. 3.

positive anomalies being recorded when the rainfall is in excess, and negative anomalies when the rainfall is in defect; and so far as can be judged, there are no independent variations in the fundamental source of heat.

PROCEEDINGS AT THE MEETINGS OF THE SOCIETY.

May 21, 1902.

Ordinary Meeting.

WILLIAM HENRY DINES, B.A., President, in the Chair.

GEORGE PROCTER CARLESS, M.Inst.C.E., Furze Platt, Maidenhead;
JOSEPH C. CUSTODIS, 6A Norfolk Row, Sheffield; and
KUMAR RONENDRA NARAYAN ROY, Bahadur, Joydelpur, Bengal,
were balloted for and duly elected Fellows of the Society.

The following communications were read:—

1. "REPORT ON THE WIND FORCE EXPERIMENTS ON H.M.S. 'WORCESTER,' AND AT STONENESS LIGHTHOUSE." By W. H. DINES, Pres. Roy. Met. Soc., and CAPT. D. WILSON-BARKER, F.R.S.E. (p. 217).

2. "THE CORNISH DUSTFALL OF JANUARY 1902." By HUGH ROBERT MILL, D.Sc., LL.D., F.R.S.E. (p. 229).

June 18, 1902.

Ordinary Meeting.

RICHARD INWARDS, F.R.A.S., Vice-President, in the Chair.

LIONEL HERBERT PROUD, Teng Jueh, Bhamo, Burma; and
HUGH VALLANCE, M.R.C.S., D.P.H., Meadvale, Redhill,
were balloted for and duly elected Fellows of the Society.

The following communications were read:—

1. "ENGLISH CLIMATOLOGY, 1891-1900." By F. CAMPBELL BAYARD, LL.M., F.R.Met.Soc. (p. 253).

2. "EARTH TEMPERATURE OBSERVATIONS RECORDED IN UPPER INDIA." By W. L. DALLAS (p. 283).

CORRESPONDENCE AND NOTES.

Investigation of the Upper Atmosphere by means of Kites.—During the past summer the investigations as to the temperature and humidity of the upper air, referred to in the Report of the Council (p. 171), have been carried on by Mr. W. H. Dines over the sea off the West Coast of Scotland.

The inquiry was inaugurated by a Joint Committee of the Royal Meteorological Society and of the British Association, with the double purpose of ascertaining if the temperature gradient over the ocean is different from that over the land, and of comparing the temperature on the summit of Ben Nevis with that of the free air in the neighbourhood at the same elevation.

The observations were made by means of kites, which were flown every day excepting Sundays from the deck of a small steam tug during a period commencing on July 8 and ending on August 26. No difficulty was experienced in starting, flying, or recovering the kite during any weather that occurred, but light winds were very prevalent, and on calm days it was not possible to reach

more than a few thousand feet. The tug could not steam more than 8 knots; with a faster vessel heights of at least a mile might have been obtained every day. The average height reached was 4000 feet; the best results being 5300 feet with one kite, 8950 feet with two kites, 12,000 feet with three kites, and 14,500 feet with four kites.

The results have not yet been fully worked up, but much interesting information was obtained. The temperature gradient over the sea was found to be considerably less than its average value over the land, and it was also found that the Ben Nevis temperature was lower than that of the air at the same level some sixty miles to the south-westward. The upper currents were found to differ in direction from those below much less than was expected. As a general rule, the humidity increased up to a level of about a mile, and then decreased.

The cost of the experiments has been about £280, and it is hoped that they may be continued, if the difficulty of obtaining funds for the purpose can be overcome. This is the more desirable since Great Britain, and particularly its western coasts, lies near the ordinary track of the cyclonic disturbances, and a knowledge of the conditions there prevailing is especially valuable. Unfortunately we are far behind most other civilised nations in this form of investigation.

Convention of United States Weather Bureau Officials.—The second triennial Convention of United States Weather Bureau Officials was held at Milwaukee, Wis., August 27-29, 1901. This was the largest and most successful convention yet held, there being 100 present. The report of the proceedings, which has recently been published by the Weather Bureau, is a volume of 246 pages.

Prof. Willis L. Moore was the President, and delivered the opening address. There were several sections, each of which had its own chairman, viz. "Educational," Dr. W. F. R. Phillips; "Forecasts and Forecasting," Prof. E. B. Garriott; "Records and Reports," Prof. A. J. Henry; "Climate and Crop Service," J. Berry; and "Instruments and Exposure," Prof. C. F. Marvin.

All the papers communicated to the Convention are printed in full, together with the discussion thereon. Several are illustrated by charts and diagrams; and a paper on "Fog Studies" is accompanied by a number of photographs showing some very pretty effects of fog formation.

Eclipse Meteorology and Allied Problems.—The United States Weather Bureau has issued a report by Prof. F. H. Bigelow on the operations in connection with the observations of the total eclipse of the sun, May 28, 1900. This is based upon the records of the expedition to Newberry, S.C.; upon the special meteorological observations at 62 Weather Bureau stations located within 500 miles of the centre of the track of totality; upon a considerable number of voluntary special observations executed within the belt of the umbra; and upon a study of various problems in solar and terrestrial meteorology.

Prof. Bigelow says that, "looking at the meteorological effects broadly, it is safe to conclude that there was a lowering of temperature by about 3° or 4°, a lowering of the vapour tension by about ·007 in., and a decrease in the wind velocity by about 1 mile per hour, caused by the eclipse shadow. There was, on the other hand, no distinct cyclonic circulation of any kind, the observed motions of the air being due simply to relative land and water changes of temperature. Mr. Clayton has drawn a very different conclusion[1] from his observations of this eclipse, to which I took an exception in my review of his report."

From a discussion of the observations on the phenomenon of the shadow bands which are seen just before the total eclipse occurs, and also just after the

[1] *Quarterly Journal of the Royal Meteorological Society*, vol. xxvii. p. 269.

shadow passes an observer situated in the path of the totality, Prof. Bigelow draws the conclusion that the shadows were crescent shaped, and had a flickering motion as if struggling through two or more conflicting movements in the atmosphere itself. He says that there seem to be decisive arguments against the idea that the shadow bands are a diffraction phenomenon in any way. On the other hand, the images of the sun, or the partial discs which are seen on the ground underneath the leafy foliage of a tree, projected through the light-spaces between the leaves, seems to be a suggestive picture of the process which is involved. Several independent observations showed that the bands had a crescent shape, like the disappearing or the appearing thin crescent of the sun at the second and third contacts respectively. The author believes that the edge of the umbra for a considerable distance from the theoretical geometrical edge is in reality made up of patches of shadow and patches of light, caused in part by the meteorological air-currents of the upper and lower strata, and by the thrusting into the atmosphere of a distinctly colder cone, which sets up undulations and disturbances near its surface that must influence the appearance of the rays of light passing through them. The separate flickering bands may be thus referred to the independent air-currents of the atmosphere, and the irregular absorption, refraction, and reflection of light on the roughly constructed edge of the umbra may be likened to the effect of the broken foliage on the sun's image, whereby a multitude of separate discs are produced on the ground beneath it. In this way the single thin crescent of the sun at the moment before totality, by passing through such a semi-opaque medium which must surround the umbra, may be multiplied into numberless images, and these would also possess the wavy and flickering features so uniformly ascribed to them by many observers.

Rainfall Maps of the United States.—The United States *Monthly Weather Review* for April 1902 has a collection of articles on "Rainfall and Charts of Rainfall," and is also accompanied by a relief chart of the United States and two maps of annual rainfall. The first rainfall map is that prepared by Mr. H. Gannett of the United States Geological Survey, and the second is that prepared by Prof. A. J. Henry of the Weather Bureau. The latter is based on 31 years of observations at the regular Weather Bureau stations, 1871-1901, and on a large number of records from voluntary observers. The total number of records used in constructing this map was 734. Of course this is a very small number for such a large area as the United States, and so the map can only furnish a general view of the distribution of rainfall. Prof. Henry fully recognises this, for he says: "The purpose of a rainfall chart is not to furnish accurate detailed data to the engineer, but rather to serve as a graphic aid in quickly determining the general geographical distribution of rainfall."

In order that the readers of the *Monthly Weather Review* might have the advantage of some acquaintance with European work on this subject, and especially with the view and principles that guide in the preparation of rainfall charts, the editor, Prof. Cleveland Abbe, gives a large number of selections from published works and recent correspondence, preceded by some remarks of his own on points that seem to be of importance.

Pressure and Temperature Results for the great Plateau of South Africa. Mr. J. R. Sutton has recently communicated to the South African Philosophical Society a paper on the above subject. The paper contains the preliminaries of an attempt to make a systematic comparison between the temperatures and pressures of the air over a plateau and corresponding coast station on much the same lines as the comparisons which are made between the summit and base of a mountain at two of the most favourable geographical positions it is possible to combine, and with what are perhaps the best materials

ever used for the purpose in South Africa. Plateau meteorology has a special interest all its own. Observations taken upon the summit of an elevated peak are important, because they tell us roughly something of the conditions prevailing in the free air at the same altitude, but balloons and kites give results which are superior in every way, excepting that continuity and regularity are not yet possible. Balloons or mountains, however, tell us only of the air: this great South African plateau gives us something more than a rough notion of what the climate of a great portion of the earth's surface will be like in ages to come, when the cooling earth has absorbed a considerable volume of its liquid envelope.

Mr. Sutton says that "we may regard the lagging in the differences of mean pressure as a peculiarity differentiating a tableland from a mountain in a germane latitude. The actual process seems to be much in this way:—

"1. The annual mean temperature of the air immediately over the tableland being much greater than that of the free air over the coast at the same elevation, the layers of equal pressure that would otherwise be level planes are expanded upwards in surfaces that follow the contour of the land. Those portions of the surfaces protruding thus over the elevation proper to their given pressures push outwards against the normal surfaces over the coast—not sliding upon each other as von Siemens has truly said—until equilibrium is established. That is, for any given latitude the barometer would read lower on the tableland and higher on the coast than it would if the tableland were replaced by a mountain of the same altitude, because of this outward extension.

"2. Starting now in the height of summer, when the temperatures over the tableland are the greatest possible, we have at any instant the whole atmospheric envelope of the southern hemisphere expanded upwards, the tendency of which is to decrease the differences of pressure between upper and lower stations. But the air being expanded over the high land not simply in terms of its altitude, but according to its temperature, the excess of volume presses coastwards, counteracting more or less completely the processes that make for a minimum pressure-difference.

"3. During February pressures are rising generally in the southern hemisphere. Also the temperature is rising over the coast, but falling over the tableland; that is, the pressure surfaces are still rising over the coast, but have begun to sink over the interior. More of the inflow from the north, therefore, goes to the tableland stations than to the coast.

"4. During March temperatures are falling generally, and pressures are rising; the surfaces of equal pressure are tending to sink. But the temperatures of the upper stations are falling very much faster than those of the coast, and hence a small excess of the still expanded air (it still being warmer than the mean) is pressing inwards.

"5. During April and May temperatures are falling most rapidly at inland and coast stations alike. The pressure surfaces are still of themselves tending to sink faster over the interior than over the coast, but now it would seem are lost in the maximum effect of the general inflow from the north. In a lesser degree the same applies to June. There is some irregularity in the behaviour of the barometer at this season, which seems to be due to the barometric depression that annually (probably) spreads over the land for a fortnight or so towards the end of May.

"6. In July the mean temperatures of the tableland cease falling, and, indeed, saving for the annual cold wave of the month, would be actually rising, as the maximum temperatures are in spite of the cold wave. At the middle stations and on the coast, however, the fall continues both by night and by day. That is, the pressure surfaces over the coast and the slopes are still sinking, while over the higher land they are sinking no longer. At this time also the general pressure over the southern parallels is practically stationary at its highest

amount. So the crest of the stationary, or ascending pressure, surfaces are free to extend laterally, adding something to the coast pressures and deducting something from those of the interior.

"7. In August the same state of things prevails. For although the temperature rises slightly over the coast, the rise on the tableland is at least four times as great; and thus, while the seasonal fall of pressure has well set in over the whole southern hemisphere, it is checked a little on the coast and increased on the tableland by the outward expansion arising from the more rapid increase of temperature. In September the pressure surfaces are rising generally, and the differences begin again to decrease.

"8. In October there is another increase in the difference of pressure. It is very plain at Aliwal North and Kimberley, and appears as a considerable temporary check in the curve rates of Philippolis and Umtata. Now at the coast stations the monthly rate of increase of temperature augments far into the summer, reaching its maximum from November to December. On the tableland the maximum rate is reached from August to September. The middle stations seem to feel the influence of both, having a marked break in their rates of temperature increase from September to October. Corresponding to this is the marked October decrease in the rate of the fall at Durban, where for pretty well a whole month the pressure curve lies above the inverted Kimberley temperature curve. It is not unlikely that the check to the rate of rise of temperature at the middle stations may also indicate a sufficient check to the rise of the pressure surfaces to allow the expanding air of the tableland—which experiences no such check—to again, temporarily, push outwards over the coast. The check of the temperature increase concerns the maximum almost entirely.

"It appears that the Durban pressure curve falls below the inverted Kimberley temperature curve in autumn, and above it in spring, whereas the Kimberley pressure curve is above its inverted temperature curve in summer and below it in winter. Of course it will be understood that the above sketch aims at neither completeness nor great exactitude. That, unfortunately, is out of the question, and will so continue until meteorology is better served by the Legislature. There are chances here, too, for kites and balloons. Nor is it quite clear why the Kimberley wind-vane tends to make one complete, if at times vacillating, clockwise rotation per annum. That one depends to some extent and in some way upon the other is a reasonable idea. Certainly the Kimberley diurnal wind stratum is very shallow, and possibly the annual stratum is so also. The seasonal transfer of air from one hemisphere to the other may take place at a great altitude, and the transfer from coast to the tableland and back somewhere between, in the middle reaches. The barometer necessarily integrates the combined effect of the three movements."

RECENT PUBLICATIONS.

Annals of the Astronomical Observatory of Harvard College. Vol. XLIII. Part II. Observations and Investigations made at the Blue Hill Meteorological Observatory, Massachusetts, U.S.A., in the years 1899 and 1900, under the direction of A. LAWRENCE ROTCH. Cambridge. Published by the Observatory, 1902. 4to.

This volume contains the regular observations made during the years 1899 and 1900; a summary for the lustrum 1896-1900; a discussion by Mr. Sweetland of the visibility of distant objects as affected by meteorological conditions, based on five years' observations; and a discussion by the same author of the

temperatures recorded at Milton during the past fifty years. There is also added a bibliography of "Published references to the work of the Blue Hill Observatory from 1896 to 1900," which contains the most important articles relating to the Observatory and its work, published by members of its staff and others during the last five years.

British Rainfall 1901. On the Distribution of Rain over the British Isles during the year 1901, as observed at about 3500 Stations in Great Britain and Ireland, with Articles upon various Branches of Rainfall Work. Compiled by H. SOWERBY WALLIS, and HUGH ROBERT MILL, D.Sc., LL.D. London, 1902. 8vo. 60 + 252 pp. and 6 plates.

The number of rainfall records published in this volume are 2616 for England, 253 for Wales, 442 for Scotland, and 195 for Ireland, the total being 3506, an increase of 13 on the previous year. The year 1901 was dry in every division of the British Isles, as will be seen from the following figures:—

England and Wales .	29·83 ins.	Difference from average	− 13 per cent.
Scotland	41·04 ,,	,, ,,	− 8 ,,
Ireland	40·33 ,,	,, ,,	− 4 ,,

The largest rainfall during the year was 186·70 ins. at Glaslyn, Snowdon; and the least 12·76 ins. at Foulness, Essex. The maximum fall in one day was 5·66 ins. at Dungeon Ghyll, Westmorland, on November 19.

In addition to the usual information and data bearing on rainfall, this volume contains an article by Dr. H. R. Mill on "The Average Rainfall of the Decades 1880-89 and 1890-99." The author lays stress on the very considerable difference between the mean of one ten-year period and that of another at the same station, and on the very slight difference between the mean of one thirty-year period and that of another, for on this important fact the trustworthiness of long averages depends. The variations of average rainfall in different parts of the British Isles during the last three decades were:—

	1870-79	1880-89	1890-99	1870-99
England and Wales .	107 per cent.	100 per cent.	93 per cent.	100 per cent.
Scotland . . .	103 ,,	97 ,,	100 ,,	100 ,,
Ireland . . .	103 ,,	99 ,,	98 ,,	100 ,,

Meteorologische Zeitschrift. Redigirt von Dr. J. HANN und Dr. G. HELLMANN. March—July 1902.

The principal articles are:—"Cirkulation relativ zu Erde": von V. Bjerknes (12 pp.). This is a mathematical discussion of the laws of atmospheric circulation.

"Das Klima Juiz de Fora im Staate Minas-Geraes, Lat. 21° 45′ S., Long. 43° 18′ W.": von Prof. F. M. Draenert (12 pp.). This is the third of Prof. Draenert's papers on the climate of the interior of Brazil. Minas-Geraes is a well-known district for mineral specimens. Juiz de Fora is an old German colony, and the observations for six years have been furnished by Dr. L. Creuzol. The town lies in the deep valley of the river Parahybuna, and this naturally affects the humidity, while the precipitous cliffs reflect heat to the town and raise its temperature. The different elements are carefully discussed.

Among the "Kleinere Mittheilungen" we find two useful papers: one on the climate of Constantinople, with results for 40 years for pressure, 47 for temperature, and 48 for rain; the other is on the climate of Peru, from the *Annals* of the Harvard College Observatory.

"Zur täglichen Periode des Niederschlages": von Dr. P. Polis (17 pp.). The

indefatigable Director of the Observatory at Aix-la-Chapelle has given us an elaborate paper on the diurnal range of rain. He takes 9 stations : Greenwich, Hamburg, Aix-la-Chapelle, Basle, Potsdam, Vienna, Trieste, Upsala, and Pawlowsk, and he counts Greenwich and Aix-la-Chapelle as maritime stations ! His chief results are as follows :—1. In Northern and Central Europe the summer and winter rain curves are strongly contrasted *inter se*, the summer showing an afternoon maximum, the winter a maximum between 8 and 10 a.m. 2. The maritime stations have more marked curve in winter, the continental in summer. 3. The diurnal period at Aix varies with the seasons. The daily period in winter has a decided connection with the position of the station as regards the centres of depression.

"Ueber die Beziehung zwischen Temperatur und Luftbewegung in der Atmosphäre unter stationären Verhältnissen" : von J. W. Sandström (11 pp.). This is a mathematical discussion on the basis of Bjerknes' hydrodynamical formula. The author gives four theses, which it may be interesting to reproduce. (1) If the clouds move more rapidly than the wind at the earth's surface, and you place yourself in the path of the wind (with your back to it) the temperature is higher on the right hand than on the left. (2) If the clouds move less rapidly than the wind at the earth's surface, and you stand facing the wind, the temperature will be higher on your right than on your left. (3) If the clouds move more rapidly than the wind at the earth's surface, the cyclones have warm centres. If the clouds move less rapidly than the wind, the reverse is the case. (4) If the clouds move more rapidly than the wind on the earth's surface, there is an ascending current in the anticyclones, and *vice versa* when the clouds move less rapidly than the wind.

"Die Wolf'schen Tafeln der Sonnenfleckenhäufigkeit" : von A. Wolfer (8 pp.). This is a rediscussion of Wolf's tables, and as a final result Herr Wolfer gives as mean interval from minimum to maximum 5·16 years, and from maximum to minimum 5·96 years.

"Langley's neuere Untersuchungen der ultrarothen Sonnenstrahlung" : von Dr. Felix M. Exner (6 pp.). This is an abstract of Langley's Bolometer work, from the *Annals* of the Astrophysical Observatory of the Smithsonian Institution for 1900.

"Ueber den Einfluss der Schneedecke auf die Temperatur der Erdoberfläche" : von W. Bührer (7 pp.). This is an investigation into the influence of snow on the earth temperature. Dr. Bührer finds that a snow sheet of even 1 centimeter in depth has a decided effect, but the maximum effect is produced by a covering of 20 centimeters, and no further influence is traceable by increase in the thickness of the snow covering.

"Ueber die Höhe der homogenen Atmosphäre und die Masse der Atmosphäre" : von Dr. Nils Ekholm (12 pp.). This is a mathematical discussion mainly directed to criticise and correct a paper on the same subject by Prof. Mascart in the *Comptes Rendus*, vol. cxiv., 1892.

"Ueber klimatologische Mittelwerthe für ganze Breitekreise" : von Prof. W. von Bezold (4 pp.). This is an abstract of a paper in the *Sitzungsberichte* of the Berlin Academy for 1901, with a careful summary of the contents by Dr. Hann.

"Mittlere Bewölkung zu Utrecht berechnet aus den 45jährigen Beobachtungen von 1851 bis 1895 und Uebersicht der Gewitter im Königreiche der Niederlanden" : von A. J. Monné (6 pp.). These are interesting papers on clouds and thunderstorms ; but the matter is mainly tabular, and so not suited for abstraction.

"Weitere Beiträge zum Klima von Recife (Pernambuco)" (5 pp.), and "Das Klima von Parahyba do Norte" (4 pp.) : von Prof. F. M. Draenert. The author, to whom we owe so many valuable communications on the climate of Brazil,

has given two papers on the climate of these two stations. The period of observations is short—only three years; but still we must be thankful for small mercies from Brazil.

Symons's Meteorological Magazine. Edited by HUGH ROBERT MILL, D.Sc., LL.D. July—September 1902. Vol. XXXVII., Nos. 438-440. 8vo.

The principal articles are:—"The Moon and Rainfall," by W. Ellis, F.R.S. (3 pp.). This is a criticism of the method adopted by Mr. MacDowall in his communications on the supposed influence of the moon on rainfall. In a subsequent number Mr. MacDowall replies to Mr. Ellis's criticism.—"The Weather of June and the Rainfall of the first half of 1902" (2 pp.).—"The Ipswich Storm of July 1," by E. R. Turner (1 p.). During a thunderstorm fully 3 inches of rain fell between 0.30 and 2.30 p.m.—"Dew in Rain-Gauges," by J. Baxendell (1 p.).—"The Ben Nevis Observatories" (3 pp.). This deals with the question of the possible closing of the Observatories at the top of Ben Nevis and in Fort William.—"Meteorological Work at Markree Observatory," by F. W. Henkel (4 pp.). This Observatory, which is at Collooney, in the county of Sligo, Ireland, was founded by the late Mr. E. J. Cooper in 1824, and meteorological registers have been kept in a more or less complete manner from that date until the present time. Mr. Henkel, who has been in charge of the Observatory since 1898, gives in this paper the results of the various meteorological observations.—"The Rainfall of August" (2 pp.). The rainfall was in excess of the average in the south-east and some other parts of England, but was below the average in Ireland and the east of Scotland.—"The Rainstorm of September 2-3, 1902" (1 p.). Very heavy rainfall over the north-east of Ireland; more than 2 inches were measured at a number of stations in and around Dublin, while at Carrick-on-Suir, in the south, the amount was 3·55 ins.—"A Short Period of Solar and Meteorological Changes," by Sir Norman Lockyer, F.R.S., and W. J. S. Lockyer, Ph.D. (2 pp.). This is an abstract of a paper read at the Royal Society on June 19.—"An African Rainmaker," by S. P. Hyatt (2 pp.).

The Meteorology of the Ben Nevis Observatories. Part II. Containing the Observations for the Years 1888, 1889, 1890, 1891, *and* 1892, *with Appendices.* Edited by ALEXANDER BUCHAN, LL.D., F.R.S., and ROBERT TRAILL OMOND. Forming Vol. XLII. of the *Transactions of the Royal Society of Edinburgh.* 4to. 552 pp. Edinburgh, 1902.

The meteorological observations made at the Ben Nevis Observatory, and at the Public School, Fort William, from the opening of the Observatory in 1883 to the end of 1887, were published in the *Transactions*, vol. xxxiv., along with a preliminary discussion of some of the results deduced from them. The present volume contains the full detailed observations made at the Ben Nevis Observatory, 1888 to 1892; at the Public School, Fort William, 1888 to 1890; and at the Fort William Observatory from August 1, 1890, to December 31, 1892.

In the Appendix there are summaries of several papers that have appeared in the publications of the Royal Society of Edinburgh and the Scottish Meteorological Society, as well as papers written specially for the volume. The subjects treated of in these papers include discussions of changes connected with fine and cloudy weather, and a report on the observations of atmospheric dust, including in each case not only the results at the Ben Nevis and Fort William Observatories, but also observations at other places. There are also several papers on the relations of barometric pressure and temperature at the two Observatories, and the reduction to sea-level of the Ben Nevis barometer readings.

The Climate of Western Australia. From Meteorological Observations made during the years 1876-99. Compiled by W. ERNEST COOKE, M.A., Government Astronomer. Perth, 1901. Foolscap. 128 pp. and 23 maps.

Meteorological observations were first officially recognised in Western Australia in the year 1876, when a meteorological branch was added to the Surveyor General's Department, and readings of the barometer, temperature, etc. were commenced under the direction of Sir Malcolm Fraser. In 1877 Mr. M. A. C. Fraser was appointed Observer, and held that office until February 1896, when it was decided to establish an astronomical observatory, and to transfer the charge of the Meteorological Department thereto. Mr. W. E. Cooke was appointed Government Astronomer, and is responsible for the present volume.

The work is divided into three parts:—I. A general description of the types of weather most frequently experienced; II. A general description of the climate, with special reference to that of Perth; and III. Climatological Tables, from the commencement of records up to the end of 1899, with maps.

Part I. is considered under two principal aspects, winter and summer:—

The Winter Type.—The main features of weather maps during the winter months (April or May to October) are:—(1) High pressure between latitudes 22° and 32°, with falling gradients north and south; (2) Fine, bright, crisp weather throughout the tropics; (3) A succession of "lows," or storm areas traversing the ocean immediately south of the continent from west to east.

The Summer Type (Overland "Lows" and "Willy-Willies").—In normal summer weather there is usually a moderate "high" extending along the south coast, or over the ocean still farther south, with falling gradients thence northwards. This condition is interrupted by two kinds of disturbance. A "low" of the winter type may pass along well to the southward, or a "low" may come down from the tropics. These types of weather are illustrated by typical maps.

Part II. deals with the climate of Perth and the south-west and south coastal districts. The following Table shows the mean results for the station at the Botanic Gardens, Perth:—

Months.	Barometer.	Temperature. Means.		Temperature. Extremes.		Rainfall.	
		Max.	Min.	Mean.	Max.	Min.	Total.	No. of Days.
	ins.	°	°	°	°	°	ins.	
January	29·935	88·0	62·6	75·3	116·7	46·0	·33	2
February	29·954	88·6	62·9	75·8	113·8	49·0	·43	3
March	30·024	84·7	60·9	72·8	106·2	46·0	·84	4
April	30·114	77·7	54·7	66·2	106·5	41·0	1·83	7
May	30·116	70·2	50·5	60·4	92·0	34·0	4·87	13
June	30·100	64·7	47·1	55·9	81·0	31·2	6·47	16
July	30·144	63·9	46·1	55·0	75·2	33·0	5·89	16
August	30·112	65·5	47·1	56·3	83·5	33·6	5·70	17
September	30·094	68·8	49·4	59·1	89·0	35·0	2·96	13
October	30·058	72·7	52·2	62·4	97·0	38·0	2·05	11
November	30·024	79·3	57·0	68·2	105·0	41·0	·87	5
December	29·961	83·5	60·4	72·0	114·0	47·0	·66	4
Year	30·053	75·6	54·2	64·9	116·7	31·2	32·90	111

After the observations referred to above, there follows observations for various periods from 32 stations, and then Part III. containing average climatological tables for the whole colony.

The rainfall values given in the tables are rather confusing, as the decimal point had been left out all through the volume.

INDEX

Abraham (J. T.), elected, 103
Address, Presidential, 53
Africa, South, Meteorological notes in, 105
Annual General Meeting, 104
Apostoloff (S. B.), elected, 212
Apparatus for measuring wind-pressure, Prize competition for, 106
Arctic Seas, State of the ice in, 1901, 157
Armstrong (F.), elected, 103
Atmosphere, Investigation of the upper, by means of kites, 1, 300
Atmospheric circulation, Mechanical principle of, 33
———— dust, 68
———— transparency, Further observations and conclusions in relation to, 19
Auditors, 34

Bacon (Rev. J. M.), elected, 34
Balance-Sheet, 174
Barograph trace during typhoon, August 2-3, 1901, 39, 212
Barrow (B.), Obituary notice of, 184
Bates (Rev. J. C.), Obituary notice of, 185
Bayard (F. C.), English Climatology, 1891-1900, 253
Bay of Bengal, Cyclonic storms in, 42
Books purchased during 1901, 197
Bourhill (H.), elected, 212
Bright sunshine, Registration of, at Mauritius, 39
British Islands, Prevalence of gales on the coasts of, 1871-1900, 121
Brodie (F. J.), The prevalence of gales on the coasts of the British Islands during the 30 years of 1871-1900, 121
Brown (A.), elected, 34
Brown (W. I.), elected, 103
Buchan (Dr. A.), awarded the Symons Memorial Medal, 102, 104
Buchanan (J. Y.), elected, 34
Buckney (D.), elected, 212
Butterworth (A. S.), elected, 212

Campbell (Rev. J. A. L.), Obituary notice of, 185
Capello (Admiral J. C. de B.), Obituary notice of, 186
Carless (G. L.), elected, 300
Chance, Element of, applied to meteorological problems, 53
Changes in the vertical, Meteorological phenomena in relation to, 9
———, Solar and meteorological, 281
Clarke (C. H.), elected, 34
Climate of Manila, 101
Climatology, English, 1891-1900, 253
Cloud, Formation of, 168
Clouds, 159
———, A note on the thermal relations of, 95
———, Cumulus, formed by smoke, 112, 214
———, Panoram pictures of, 35
———, Photograph, 41
Congress, Meteorological, Mexico, 109
Conroy (J.), Obituary notice of, 186
Convention of United States Weather Bureau Officials, 301
Cornish dust-fall of 1902, 229
Correspondence and Notes, 35, 105, 212, 300
Council and Officers, 1902, 104
———, Report of the, 169
Cowl Committee, Report of the, 38
Creswell (W. T.), elected, 103
Crimp (W. S.), Obituary notice of, 186
Culley (E. H.), elected, 105
Cummins (Major H. A.), elected, 34
Cumulus clouds formed by smoke, 112, 214
Cunningham (Surg.-Major C. L.), elected 212
Curtin (W. H.), elected, 103
Custodis (J. C.), elected, 300
Cyclonic storms in the Bay of Bengal, 42

Dallas (W. L.), Earth temperature observations recorded in Upper India, 283
Dalton (Dr. J. H. C.), elected, 212
Damage by lightning at Higher Brookland, Devon, June 30, 1901, 27
Deaths and fires caused by lightning in Hungary, 38
Debnam (A. W. J.), elected, 34
De la Motte (F. A.), elected, 103
"De Witte typhoon," August 1-6, 1901, The, 107
Dickson (H. N.), Mean temperature of the atmosphere and the causes of glacial periods, 32
Dines (W. H.), The element of chance applied to various meteorological problems, 53

Dines (W. H.), and Wilson-Barker (Capt. D.), Report on the wind force experiments on H.M.S. *Worcester*, and at Stoneness Lighthouse, 217
Distribution of fog in Switzerland, 252
Dixon (E. W.), elected, 34
Dixon (F. J.), elected, 34
Donations received, 1901, 198
Druce (F.) elected auditor, 34
Dust, Atmospheric, 68
Dust-fall of January 1902, The Cornish, 229

Earth temperatures recorded in Upper India, 283
Eclipse meteorology and allied problems, 301
Edinburgh rock thermometers, Observations of, 41
———— Royal Observatory, Report from, 208
Edwards (C. W.), elected, 103
Edwin (Capt. R. A.), On the mechanical principle of atmospheric circulation, 33
Element of chance applied to various meteorological problems, The, 53
English climatology, 1891-1900, 253
Exploration of the atmosphere at sea by means of kites, 1
Eyre (Major F. H. D.), Obituary notice of, 188

Fires caused by lightning in Hungary, 38
Floating clouds, Thermal relations of, 95
Flower (Major L.), Obituary notice of, 188
Fog in Switzerland, Distribution of, 252
Formation of cloud, 168
Froc (L.), The barograph trace during the typhoon of August 2-3, 1901, 212
Further observations and conclusions in relation to atmospheric transparency, 19

Gales, Prevalence of, on the coasts of the British Islands, 1871-1900, 121
Gilbert (Sir J. H.), Obituary notice of, 189
Glacial periods, Causes of, and mean temperature of the atmosphere, 32
Greenwich, Royal Observatory, Report from, 208
Greenwood (J. P.), elected, 34
Grinlinton (F. H.), elected, 34
Grover (C.), Damage by lightning at Higher Brookland, Devon, June 30, 1901, 27

Hardcastle (F. E.), elected, 34
Harmer (W. S.), elected, 103
Heap (R.), Obituary notice of, 190
Hepburn (A. E.), elected, 105
Hepper (J.), elected, 105
Hepworth (Com. M. W. C.), Atmospheric dust, 68
Higher Brookland, Damage by lightning at, 27
Hoddinott (E.), elected, 105
Hoseason (W. S.), Remarkable phosphorescent phenomenon observed in the Persian Gulf, April 4 and 9, 1901, 29
Hourly velocity of wind at Rousdon, 36
Hungary, Deaths and fires caused by lightning in, 38

Ice in the Arctic Seas, 1901, The state of, 157
India, Earth temperatures in Upper, 283
Inspection of stations, Report on the, 1901, 178
Investigation of the upper atmosphere by means of kites, 300

Jackson (W. S.), elected, 34
Jacques (H. L.), elected, 103
Jolliffe (C. H.), elected, 212
Jones (J. P.) elected, 103
Just (J. A.), elected, 105

Kershaw (G. B. de B.) elected, 34
Kew Observatory, Report from, 208
Kites, Exploration of the atmosphere at sea by means of, 1
———, Investigation of the upper atmosphere by means of, 300

"La lune mange les nuages," 95
Lambert (Commander H. M.), Obituary notice of, 190
Lantern slides, 205
Lawton (C. H.), elected, 103
Lemmoin-Cannon (H.), elected, 103
Lewis (F. B.), elected, 103
Lightning, Damage by, at Higher Brookland, Devon, 1901, 27
————, Deaths and fires caused by, in Hungary, 38
————, Loss of life by, in the United States, 214
————, Photographs, 167
Loss of life by lightning in the United States, 214

Manila, Climate of, 101
Marks (T. T.), Obituary notice of, 190
Marriott (W.), Report on the inspection of stations, 1901, 178
Martin (A. W.), Obituary notice of, 191
Mauritius Meteorological Society, 35
————, Registration of bright sunshine at, 39
Mawley (E.), Report on the phenological observations for 1901, 69
Mayer (F. W.), elected, 34
Mean temperature of the atmosphere and the causes of glacial periods, 32
Mechanical circulation of the atmosphere, 33
Medal, Symons memorial, 102, 104
Meetings, Proceedings at the, 34, 103, 212, 300
Meldrum (Dr. C.), Obituary notice of, 191
Mellish (H.), Cumulus clouds formed by smoke, 214
Meteorological and solar changes, 281
———— congress, Mexico, 1900, 109
———— notes in South Africa, 105
———— Office, Report from, 205

Meteorological Office, Rome, 35
———— phenomena in relation to changes in the vertical, 9
———— problems, The element of chance applied to, 53
———— Society, Mauritius, 35
Meteorology, Eclipse, and allied problems, 301
———— in New South Wales, 1901, 94
Mexico, Meteorological Congress, 1900, 109
Mill (Dr. H. R.), The Cornish dust-fall of January 1902, 229
Milne (J.), Meteorological phenomena in relation to changes in the vertical, 9
Mukerju (R. S. K. K.), elected, 34

National Physical Laboratory (Kew), Report from, 208
Nesbit (D. M.), elected, 103
Netherlands, Royal Meteorological Institute of the, 211
Newby (H. M. H.), elected, 103
Newman (T. P.), elected Auditor, 34
New Premises Fund, 176
New South Wales, Meteorology in, 94
Nicol (Dr. J.), Obituary notice of, 192
Notes and Correspondence, 35, 105, 212, 300

Obituary Notices, 184
Observations of the Edinburgh Rock thermometers, 41
Observatories, Reports of, 1901, 205
Officers and Council, 1902, 104
On the mechanical principle of atmospheric circulation, 33
Ormerod (Miss E. A.), Obituary notice of, 193
Overbury (T.), elected, 34
Oxford, Radcliffe Observatory, Report from, 210

Peek (Sir C. E.), Obituary notice of, 194
Peek (Hon. Lady), elected, 103
Persian Gulf, Phosphorescent phenomenon in, April 4 and 9, 1901, 29
Phenological observations for 1901, 69
Phosphorescent phenomena in the Persian Gulf, 29
Photographs, Cloud, 41
————, Lightning, 167
Powell (A. E.), elected, 103
Power (J. B.), elected, 34
Presidential Address, 53
Press (W. J.), elected, 34
Pressure and Temperature Results for the Great Plateau of South Africa, 302
Prevalence of gales on the coasts of the British Islands, 1871-1900, 121
Prize competition for apparatus for measuring wind pressure, 106
Proceedings at the Meetings, 34, 103, 212, 300
Proud (L. H.), elected, 300
Publications, Recent, 44, 112, 215, 304
Pullar (F. P.), Obituary notice of, 195

Queensland, Weather Bureau, 211, 282

Rainfall at San Fernando, 211
——— maps of the United States, 302
Rand (R. F.), elected, 105
Recent Publications, 44, 112, 215, 304
Registration of Bright Sunshine at the Royal Alfred Observatory, Mauritius, 39
Remarkable phosphorescent phenomenon observed in the Persian Gulf, April 4 and 9, 1901, 29
Report of the Council, 1901, 169
——— of the Cowl Committee, 38
——— of Wind Force Experiments on H.M.S. *Worcester*, and at Stoneness Lighthouse, 217
——— on the Inspection of Stations, 1901, 178
——— on the phenological observations for 1901, 69
Reports of Observatories, 1901, 205
Research Fund, 176
Robinson (M. A.), elected, 105
Rock thermometers at Edinburgh, 41
Rome, Meteorological Office, 35
Rotch (A. L.), The exploration of the atmosphere at sea by means of kites, 1
Rousdon, Hourly velocity of wind at, 36
Roy (R. N.), elected, 300
Russell (Hon. F. A. R.), Further observations and conclusions in relation to Atmospheric Transparency, 19
Russell (H. C.), Meteorology in New South Wales, 1901, 94

San Fernando, Rainfall at, 211
Scott (J. L.), elected, 105
Scrutineers, 103
Shaw (W. N.), "La lune mange les nuages"—a note on the thermal relations of floating clouds, 95
Smith (B. W.), Obituary notice of, 196
Smith (H.), Obituary notice of, 196
Smith (J.), elected, 34
Smoke, Cumulus clouds formed by, 112, 214
Solar and Meteorological Changes, 281
Sound Signals and Weather, 173
South Africa, Meteorological notes in, 105
————, Pressure and Temperature Results for the Great Plateau of, 302
State of the ice in the Arctic Seas, 1901, 157
Stations, Inspection of, 178
Stoneness lighthouse, Wind force experiments at, 217
Stow (J. F.), elected, 103
Stuart (F. D.), elected, 103
Sunshine at Mauritius, Registration of, 39
Switzerland, Distribution of fog in, 252
Symons Memorial Medal, 102, 104, 169, 176

Temperature and Pressure Results for the Great Plateau of South Africa, 302
————, Earth, in Upper India, 283
———— of the atmosphere, and the causes of glacial periods, 32
Thermal relations of floating clouds, 95

Thomas (Dr. A.), elected, 212
Tornadoes, Wind force in, 40
Transparency, Atmospheric, 19
Trebeck (P. C.), Cloud photograph, 41
Tripe (J. H.), elected, 212
Twentyman (J. R.), elected, 34
Typhoon, August 2-3, 1901, barograph trace, 39, 212
————, the "De Witte," of August 1-2, 1901, 107

United States Convention of Weather Bureau Officials, 301
————, Loss of life by lightning in, 214
————, Rainfall maps, 302
Upper atmosphere, Investigation of, by means of kites, 300
—— India, Earth temperatures in, 283

Vallance (H.), elected, 300

Walkden (S.), elected, 103
Walwyn (H. W. S.), elected, 103
Warren (A.), elected, 34
Weather, and sound signals, 173
————, Bureau, Queensland, 211, 282
Wherly (S. S.), elected, 103
Whittome (P. A.), elected, 34
Wilson (J. T.), elected, 34
Wilson-Barker (Capt. D.), Clouds, 159
————————, Exhibition of panoram pictures of clouds, 35
————————, and Dines (W. H.), Report on the wind force experiments on H.M.S. *Worcester*, and at Stoneness Lighthouse, 217
Wind at Rousdon, Hourly velocity of, 36
—— Force Committee, Proceedings of, 222
—— force experiments on H.M.S. *Worcester*, 217
—— force in tornadoes, 40
—— pressure, Prize competition for apparatus for measuring, 106
Wood (C. F.), elected, 105
Worcester, H.M.S., Wind force experiments on, 217
Wrigley (N.), elected, 105

THE END OF VOLUME XXVIII.

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